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Bethlehem Meeting of the American Electrochemical Society.

Bethlehem is a quaint old town, picturesquely located in the Lehigh Valley. In recent years it has come prominently before the general public through the establishment of its Bach Festivals, and is being called by some enthusiasts the Bayreuth of America. Independent of its justification for this claim, it certainly is a delightful little town, and it needs no great power of prophecy to say that the American Electrochemical Society did a wise thing in arranging to hold its autumn meeting, in September, in Bethlehem. It has been the experience of all the other big national engineering societies that those meetings which were held in comparatively small towns were the most successful and enjoyable—we may mention as instances the Great Barrington and Ashville meetings of the Institute of Electrical Engineers. We trust that the experience of the American Electrochemical Society will be the same. In the present case, the easy accessibility of Bethlehem from New York or Philadelphia is a distinct advantage, while an admirable programme of visits to plants, excursions and other social functions has been arranged. To professional metallurgical and chemical engineers Bethlehem and its vicinity offers special attractions in its famous steel, zinc and cement works, to which visits have been arranged, as is noted in the programme published on another page of this issue. Lehigh University will be the host of the society at its professional sessions, and it is unnecessary to tell our readers that Lehigh has been among the first American universities to promote electrochemistry, electrometallurgy and physical metallurgy.

Labor-Saving Appliances in Laboratories.

Too often it is overlooked that with respect to purpose and character there is a very essential difference between the chemical laboratory of a university or college and the works-laboratory of a chemical or metallurgical industrial plant. The purpose of the chemical laboratory of the university is to make the student acquainted with chemical reactions and analytical methods. For this purpose as few labor-saving devices as possible should be placed in the hand of the student in the beginning. He should do all the work himself with his own hands in order to acquire that experimental skill without which purely theoretical knowledge is useless in practical analytical work. It is in the university laboratory that the chemist should acquire the faculty of overcoming difficulties which are liable to confront him at any time. Only by doing all the work himself can he acquire the resourcefulness and the well-balanced head which he needs more than anything else in later years in commercial work. It has been said that a physicist must be his own glass blower and his own mechanic. Nothing less should be required of the student

of chemistry. Nor is this requirement unnecessarily exacting. The spendid results obtained with the most simple means in the old classical chemical laboratories like that of Bunsen prove the value of such a course. Naturally, under such conditions the chemist is compelled to devote a very great deal of his time in the laboratory, but the time is not wasted. Even if the work appears to him tedious at times, he is thoroughly recompensed in the end. The writer remembers with pleasure the time when he constructed and wound himself some electrical measuring instruments for his own use in electrochemical work. The time spent in such work is not wasted; its investment brings interest in the form of a most intimate knowledge—not to be acquired in any other way—of the working principles of the instruments which he has to manipulate. The same is true of all apparatus and appliances used in the chemical laboratory. Of course, this principle of letting the student do all the work himself, including the construction of the apparatus which he needs, should not go too far. When once he has acquired the necessary intimacy with methods and apparatus then he is ripe to have at his disposal the labor-saving devices which the ingenuity of modern engineering has placed at the disposal of chemists.

The works-laboratory of a chemical industrial plant has to fulfill quite a different purpose. If the chemist entering a works-laboratory is worth his pay he must be assumed to be familiar with analytical work. The works-laboratory is only one link in the complex mechanism of the industrial chemical organization, and its work should be ruled by the same commercial principles of doing things with maximum efficiency as any other department of the organization. But while in other departments the development has been in the direction of reducing cost of production by substituting automatic machinery for manual labor, many managements of chemical or metallurgical works have reduced the cost of the works-laboratory by substituting, to some extent, boys for chemists. As Dr. Edward Keller points out in the most interesting paper, the first part of which is published in the present issue, this tendency is wrong in principle. Analytical work requires theoretical knowledge, experimental skill and conscientiousness—qualities which cannot be fairly expected from a boy receiving small wages. The salvation lies naturally in following up the same principle which has proved so enormously useful in all engineering work, *i. e.*, in the systematic introduction of labor-saving appliances in the works-laboratory. We believe that this has not been carried out before anywhere with such consequence as in the Baltimore works-laboratory of the Anaconda Copper Mining Co. Its description by Dr. Keller should prove interesting reading to all whom it may concern, and it may be hoped that the introduction of labor-saving devices into the works-laboratory will become more and more general. It may be said that in many works-laboratories this development is already going on. In this way the chemist of the works-laboratory will get spare time which he may apply to useful chemical work. Even if the works-laboratory is always kept separate from the research laboratory—which is undoubtedly preferable in many cases—there will be enough important chemical problems for the works-chemist to solve in spare time. Then we may hope that the works-chemist and his old and useful art of assaying may no longer be (as Dr. Keller says) "too often lightly considered by those having an excessive knowledge of chemistry and metallurgy."

The Influence of Mineral Wealth upon History.

For the past weeks the entire world had focused its attention on the little town of Portsmouth, where the representatives of two countries were playing for a great stake. Like the national game of poker it was a game of bluff, of proposals and counter-proposals, of divining the thoughts of the opponents, of frankness, secrecy, suavity and veiled force, alternating rapidly across the board of play. The diplomats were playing for a great "jackpot" of minerals—a pot not contributed to by the players but made by nature's ever-working forces. In aeons past the country of Northern China was spotted with great basins. In these basins were accumulated large peat bogs in some places, and again ferruginous waters laid down their mineral freight. The metamorphic changes of years have turned these deposits into coal and iron ore, in generous measure as has been done in the United States in Alabama and elsewhere, in England, in the Cleveland district, and in Germany in the "Minette" provinces of Alsace, Lorraine and Luxembourg. Coal and iron ore in proximity make cheap pig iron.

Coal and iron are the foundations on which is built a great commercial structure. Reports, vague and indefinite of the size of these deposits, are known to the spectators. Russia and Japan, however, have some accurate knowledge of the mineral wealth of Northern China. Careful and systematic prospecting has been done by the bureaucracy—benevolent and malevolent—and by the secret service of forehanded Japan. Coal and iron are the essentials of a modern civilization as much as wheat and corn. It is for the possession of these fields that men and treasure were sacrificed on the plains and mountains of Manchuria. For the eating of that "big fat pie" might makes right, and the mightier will become even more mighty by the possession of the prize.

There have been in the past many wars, commercial and actual, for the possession of choice bits of the earth's crust. Chile, by an aggressive war, despoiled Peru of her nitrate beds, which supply an ingredient of fertilizers of plant life and the raw material of the most important explosives. The far-seeing Bismarck brought on the Franco-Prussian war. As victor, Germany took provinces containing iron deposits, the second in size among the proven deposits of the world. And it is a curious fact that the Thomas basic Bessemer process has increased the value of these deposits by the utilization of its phosphatic slags of immense value as fertilizers. Germany won an important source of natural wealth, then unknown, in the phosphate in those oölitic ores. Another war for mineral wealth was the Anglo-Boer. England expended millions of pounds sterling and shed much good British blood to gain the control of the Rand gold deposits, made valuable only because McArthur and Forrest had made practical the selective solubility of gold ores in cyanide of potash. But gold is of secondary importance to coal, iron and agricultural wealth. It really has only a fictitious value, due to human sentiment to its beauty and to its scarcity. Things have a basic commercial

value because they satisfy real human needs. In older times Spain, England and France sent adventurous men to take the gold of America. Gold has been the bone of contention for centuries. But still, in the hands of men like Francis Drake, the source of power in those early days was still iron, bronze and wood.

In the Middle Ages the coat of mail, and later the musket, was the controlling factor in war. Nowadays the nickel in nickel-steel armor plate makes the battleship resistant to the shots of the enemy, and thus it becomes a tremendous engine of destruction. It gives a nation with battleships a differential advantage, as did the coat of mail the armed knight. In a prolonged modern war unless a new alloy of iron equal to nickel-steel is found, the possession of the nickel mines of New Caledonia and Ontario would be a similar differential advantage. Smokeless coal is another source of naval advantage. Thus it is that the sources of material wealth will always be fought for to give national supremacy. Mineral wealth is the cause of war, and once won gives the stronger greater strength. Metals are agents of destruction as well as production. Battles have been fought with metallic weapons and armor since the days of Tubal Cain. In times of war the ploughshare and sickle are wrought into sword and shield. Anthropologists tell us that human nature has changed but little in 2000 years. Then it is not remarkable that the primitive stone hatchet and wooden club are seen to be the prototypes of the armored battleship and high-power rifle. The state of prehistoric man and our modern refined civilization have the same fundamental characteristics; energy and courage to wield the weapon of offense are as necessary to-day as they always were and always will be.

That the Russo-Japanese war has been largely affected by mining and metallurgical advances is the logical outcome of natural evolution. Iron and coal are as necessary to the life and growth of a nation as are the iron of the hæmoglobin of the blood and the food of the individual man. The Japanese appreciated this, and desired the control of the iron and coal fields that Russia took from helpless China. They apparently argued that "to the victor belong the spoils." They learned it when Russia took from them the coal beds of their island of Sakhalin thirty years ago. They have not forgotten it since.

Mathematics in Engineering.

In any branch of engineering the ultimate goal is to reduce the principles and methods to exact mathematical form. Their application is then kept well in hand. In order to solve a given problem of practice, it suffices to formulate precisely the requirements, and the solution follows by cut and dried methods of calculation and with the exactness of algebra. The obvious danger of the prevalence of such methods is that the exactness degenerates into rigidity and inflexibility, while engineering practice places before us constantly changing requirements. We would deceive ourselves would we believe that we can treat an engineering problem with the same mathematical precision as, for instance, an ideal case of analytical mechanics. In engineering practice we have not to do with ideal cases, but in order to get a simple method of calculation we change the requirements of our real case, so as to get an ideal case, by introducing certain simplifying assumptions, etc. Experience teaches us within which limits we are justified to do so. When now a case arises not within these limits, we have to revise the starting suppositions as well as the whole method of calculation. The chief trouble is that in such calculations the starting point and the solution have an engineering meaning, while the links connecting the two ends of the chain are pure mathematics. The only effective remedy is that the engineer who makes the calculation keeps always in mind what the physical meaning of each and every formula is. Then the whole mathematical calculation becomes simply a statement in short-hand of the technical reasoning. All technical suppositions are clearly kept in mind, while the precision of mathematical methods prevents any logical error.

That consequent and exact technical reasoning is possible without mathematics, is conclusively proven by Faraday's life work. Yet his way of reasoning seemed obscure until Maxwell devised mechanical models or analogies for Faraday's physical conceptions, and thus brought them within the realm of mathematical calculation. It would seem that the average man needs both faculties: the ability of technical reasoning with the aid of technical (physical or chemical) conceptions (often involving a hidden hypothesis), and the ability of checking the results of such reasoning by mathematical analysis. Technical conceptions may mislead us to see in them more reality than there is in them and to apply them beyond the limits of their usefulness. Mathematical analysis is apt to let us lose sight entirely of the real phenomena which our analysis covers. A thorough blending of the methods of technical conceptions and of mathematical analysis is needed for the average man. The genius who revolutionizes sciences and arts is not thus handicapped; he devises and works out his own methods. Faraday, who revolutionized electromagnetic science and laid the cornerstone for electric engineering, worked with physical conceptions of his own. Willard Gibbs, whose revolutionary work in the thermodynamics of chemistry is being recognized more and more from day to day, gave the results of his researches in the form of pure mathematics. To make his work the common property of chemists, Gibbs must be supplemented by the chemical experimenter. Gibbs' phase rule has become the basis of a new classification of chemistry through the work of the school of Roozeboom. Gibbs' exposition of the conditions which govern chemical equilibrium has already shed a flood of light on many phenomena, but far more experimental work will be needed to appreciate in full measure the real grandeur of Gibbs' life work. When and how far his work will affect chemical and metallurgical engineering is impossible to say at present. Under present conditions the chemical and metallurgical engineer needs only a small amount of mathematical apparatus. The fundamental principles which govern all his reactions are contained in molecular equations for the calcution of the masses and energy equations for the calculation of the physical conditions under which his reactions take place. What he needs more than anything else at present, are empirical constants (specific heats, heats of fusion, etc.) for use in his thermochemical calculations.

Some Impressions at the Annual Meeting of the Society of Chemical Industry Held in England in July, 1905.

By Maximilian Toch.

In Sept., 1904, the English section visited the United States, and for a year prior to their coming a committee met at the hall of the Chemists' club on the last Friday of each month to perfect the arrangements, and the reception the English branch received, when they arrived in the United States and were taken on a tour to St. Louis and back, is now history.

When we arrived in England on the 8th of July, some thirty-five of us had been passengers on the "Campania," and the recollections of that trip are certainly not to be forgotten. The sea voyage was perfect—sunshine and smooth water every day. On the 4th of July, the inimitable Dr. Wiley conducted the Independence Celebration. When we arrived at Liverpool we felt as if we were one huge family. Our London quarters were at the Hotel Russell, which is a new hotel, situated in Russell Square, that reminds one very much of Gramercy Square, in New York, it being situated the same as Gramercy Square is, in the old residential portion of the city. The University College of London is in Gower Street, only a few minutes walk from the hotel, and the opening meeting took place at 11 o'clock Monday morning, July 10, in the lecture hall, replete with scientific history.

Let it be remembered for all time that Dr. William H. Nichols, our president, unquestionably carried off the honors of the day, and we felt justly proud of him, not only at the opening meeting but throughout the whole trip. His ability to speak extemporaneously is marvelous, but his ability to say the right thing at the right time is much more remarkable.

To give a detailed history of the pleasant trip and of all the good times that we had from London to Glasgow would form a volume of many hundred pages, so it can only be said that wherever we went the hospitality that was shown us was simply overwhelming. In London, the Lord Mayor gave us a reception, and wherever we went the Lord Mayor of that city received us, and the freedom of the city was granted us. There was one trip in particular of which we all spoke, and it was the journey in a private train from Newcastle to Edinburgh. The scenery, the train itself, the two dining cars, the excellent dinner and the condition of the weather were all of the best, and when we arrived at Edinburgh every man and woman felt in superlative condition.

The trip through Scotland calls for some comment, and as one of our party said, the only trouble with Scotch hospitality was that there was insufficient Apollinaris served with it.

On the last day, during the boat trip around Glasgow, four silver loving cups were presented to Dr. J. Lewkowitsch, Mr. Julian Baker, Mr. Gordon Salamon and Mr. Thomas Tyrer. At night the final reception was given us by the Lord Mayor, and when we parted from our many friends we felt that the British are our friends and brothers, and that the Society of Chemical Industry is stronger than ever.

Bethlehem Meeting of the American Electrochemical Society.

The eighth general meeting of the American Electrochemical Society will be held in Bethlehem, from Sept. 18 to 20. The first session will be held on Monday, Sept. 18, afternoon. Members leaving New York with the Black Diamond Express (Lehigh Valley) at 11.55, or Philadelphia at 12.30, will arrive in time for the first session. The following papers will be presented at this meeting:

R. Threlfall—"A Standard Method of Measuring the Specific Resistance of Electrolytes."

Oliver P. Watts—"Notes on the Use of Aluminium as a Reducing Agent."

G. Gin—"New Furnace for the Electrical Manufacture of Steel."

G. Gin—"Note on the Electrical Resistivity of Iron and Steels at High Temperature."

A. G. Betts—"An Electrolytic Process for Refining Silver."

A. G. Betts—"Notes on the Electrometallurgy of Antimony."

C. F. Burgess—"Report on the Electrochemical Exhibits at the Louisiana Purchase Exposition, 1904."

Charles Baskerville—"Artificial Willemite."

W. D. Bancroft—"The Chemistry of Electrochemistry."

L. Addicks—"Ammeters for Electrolytic Work."

F. D. Easterbrooks—"Electrolytic *vs.* Sulphuric Acid Parting of Bullion."

M. Toch—"Insulating Paints."

K. Von Foregger—"The Utilization of Active Oxygen, Chemically and Electrically Produced."

N. M. Hopkins—Title to be announced later.

E. F. Roeber—"Thermodynamics of the Electric Incandescent Lamp."

H. Schlundt and R. B. Moore—"The Chemical Separation of the Excited Activity of Thorium."

R. B. Moore and H. Schlundt—"Radioactivity of Some Natural Waters of Missouri."

C. F. Burgess—"Some Observations on the Influences of Arsenic in Pickling Solutions."

O. W. Brown and W. F. Oesterle—"The Electric Smelting of Zinc."

Exhibit of Voege's System of Index Collection of Swiss Electrochemical Patents, Wednesday, p. m., by C. F. Carrier, Jr.

On Tuesday afternoon the plant of the Lehigh Zinc Co. and the Bethlehem Steel Co's. world-renowned works will be visited. For Wednesday afternoon an option of either of two excursions is offered. The first is by trolley to one of the big cement works in the vicinity, the other an excursion to Mauch Chunk, including a trip around the Switch-Back. Any who remain in Bethlehem Wednesday afternoon are cordially invited to attend the opening exercises of Lehigh University.

A smoker will be held at one of the commodious club houses in Bethlehem on Monday evening. A lunch will be tendered to the visiting members by the authorities of Lehigh University, in the gymnasium, on Tuesday, Sept. 19, at 12.30 p. m.

A subscription dinner will be served at the Eagle Hotel, Tuesday evening, Sept. 19. The Eagle Hotel is to be the convention headquarters.

Besides the attractions which the beautifully situated historic town of Bethlehem offers in itself, a special programme of entertainment is provided for the visiting ladies. For Monday afternoon a carriage drive, starting from the Eagle Hotel at 3.00 p. m., has been arranged through the Bethlehems to South Mountain, with a visit to the grounds and buildings of Lehigh University. In the evening there will be an informal reception by the ladies' committee to the visiting ladies and their escorts at the residence of Professor and Mrs. J W. Richards. On Tuesday morning an excursion will be made to Easton, with a visit to the large works of the Standard Silk Co.; lunch will be taken at Huntington, followed by a visit to Wygatt Mountain and grounds and buildings of Lafayette College, while in the evening a subscription dinner will follow, as already mentioned. For Wednesday morning an excursion is planned to Nazareth, with visits to the quaint Moravian buildings, Nazareth Hall, school, Indian burying ground and the Whitefield house. For the afternoon the option of either an excursion to Mauch Chunk or the attendance of the opening exercises of Lehigh University is offered.

Any inquiries are to be addressed to the secretary of the local committee, Mr. Walter S. Landis, Met. Eng., Bethlehem, Pa.

Report of the Karlsruhe Meeting of the German Bunsen Society.

BY H. DANNEEL, PH. D., AND J. K. CLEMENT, PH. D.

The following is a concise report of the papers presented at the general meeting of the Bunsen Society for Applied Physical Chemistry, held in Karlsruhe from June 1 to 4.

ELECTROLYSIS WITH ALTERNATING CURRENT.

A paper on this subject was presented by Prof. MAX LEBLANC. When an alternating current is passed through a solution of $CuSO_4$, with copper electrodes, the metal is dissolved by one-half wave of the current (during one half of the period) and is immediately redeposited by the next half wave. The total effect is that the electrodes remain undissolved. If, however, there is an opportunity for the metal to enter when dissolved, into a compound from which it cannot be deposited, even by direct current (*e. g.*, in a KCN solution of Cu), H_2 and not Cu is liberated in one-half- period, while Cu is dissolved in the next half period, *i. e.*, the total effect observed is the solution of the metal in accordance with Faraday's law. This holds only with alternating currents of low frequency. When the frequency is so high that the Cu has not time to enter into the complex cyanic compound, the action is the same as with copper electrodes in $CuSO_4$: the total effect is no solution of Cu. With high frequencies Cu does not dissolve; with low frequencies it dissolves with 100 per cent efficiency. Between these limits the amount dissolved decreases with increasing frequency. This is true of the majority of the metals.

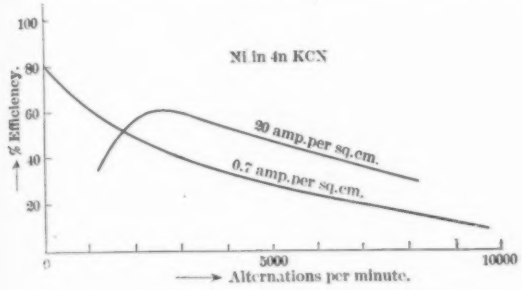


FIG. 1.—ELECTROLYSIS WITH ALTERNATING CURRENTS.

From the results of experiments, inferences may be drawn concerning the velocity with which the complex Cu cyanide compound is formed. The velocities with which substances produced by electrolysis enter into unsoluble compounds may be determined in the same way. In the Luckow process, for example, with lead electrodes in a carbonate solution, with low frequency current, white lead is formed; the lead has sufficient time to form the insoluble compound during one-half of the period of the current. With increasing frequency, the percentage output of white lead diminishes. With high frequencies no white lead is formed.

These remarks apply to symmetric alternating currents only. With an unsymmetric current waveform—for example, if the positive portion of the current wave is three times as long as the negative—and with Cu electrodes in $CuSO_4$, the total effect is the solution of Cu to the extent of 50 per cent of the theoretical amount required by Faraday's law, and this is independent of the frequency. This result is confirmed by experiment, but is true only of the electrodes with crystalline surfaces. If the Cu is heated above its melting point and suddenly cooled in alcohol, it is converted into a more stable modification which dissolves less readily. Some further deductions are drawn from this by the author, who also cites some observations as proof that the passivity of metals cannot always be explained by the assumption that the surface is charged with oxygen. In $CuSO_4$ the two modifications of copper have a difference of potential of 0.013 volts. This difference does not disappear when the electrodes are connected over night through a resistance of 170 ohms.

Brochet and Petit found that the curves whose abscissas and ordinates represent, respectively, frequency and output are abnormal for some metals. While the curve for Cu in KCN falls gradually from zero frequency and 100 per cent output, to infinitely great frequency and zero output, the curves for Ni, Fe and other metals beginning at zero frequency, rise to a maximum, and then fall with increasing frequency. Danneel has shown (*Zeitschrift für Electrochemie* 10, 741) that the cause of this phenomenon lies in the velocity with which these metals change over to the passive state. LeBlanc shows that this is the correct explanation. When a four-normal solution of KCN is electrolyzed between Ni electrodes with alternating current of current density, 0.7 amp. per square centimeter, the output curve is normal as is shown in Fig. 1. Under these conditions Ni as anode does not become passive, even with direct current. With a current density of 20 amps. per square centimeter, the curve shows the characteristic maximum. With this current density Ni becomes passive as anode with direct current.

PAINTING.

Prof. W. OSTWALD lectured on this subject. He possesses an unusual talent for painting, and has written a book on the application of physical chemistry to the technique of painting. In this he has shown that many artists are unscrupulous in that they do not apply themselves to the physical side of their art. The result is that expensive pictures are often ruined in a short time. In this paper Ostwald gives some particularly good examples of the application of physical chemistry.

It is well known that oil paintings become full of rents very rapidly when the paint has been put on too thick. The cause of this is that the canvass on which the pictures are painted stretches in the course of years, whereas the oil paint shrinks. This defect may be avoided, first by taking some other material, *e. g.*, aluminium instead of canvas; secondly, by applying the paint as thin as possible, as in the case with all old paintings, which are well preserved, *e. g.*, the Sistine Madonna. The paint on the Sistine Madonna is so thin that the threads of the canvass can be seen through it.

The shrinkage of the paint is caused by the oxidation of linseed oil which is used in mixing the colors. Ostwold shows that the process of oxidation is autocatalytic, *i. e.*, the products of oxidation themselves accelerate the process catalytically. This process is of importance for the technique of drying. The much used white lead is very poisonous and in time turns black—due to the sulphur which is contained in many colors. As a substitute for white lead, Ostwald suggests lithopon, which is not sensitive to light. He illustrated his remarks by some of his own pictures which were exhibited.

GEOLOGICAL THERMOMETER.

Prof. VAN'T HOFF in a paper on this subject pointed out that from the constitution of the natural salt beds north of the Harz Mountains in Germany, inferences may be drawn concerning the prevailing temperature on the earth at the time the salt beds were formed. For example, anhydrous Na_2SO_4 (Thenardite) is formed from sea water at temperatures above 29° C. At lower temperatures the hydrated Glauber's salt, $Na_2SO_4 + 10H_2O$ is formed. Anhydrous salts, gypsum for example, form with water a hard mass. Glauberite melts at 29° C., so this must be the temperature at which Glauber's salt is formed. But this melting-point is lowered by the presence of foreign substances. By determining analytically the amounts of the various substances contained in Glauber's salt, one may obtain an indication of the temperatures at which the natural salt beds were formed.

The following examples are given: Astrakanite, 5°; Glauberite, 10°; Thenardite, 14°; Kieserite, 18°; Leonite, 18°;

Langbeinite, 37°; Löweite, 43°; Vanthoffite, 46°. Inferences regarding the temperature may also be made from a study of the conditions under which minerals occur together (paragenesis): Löweite and Glaserite can be deposited out together only above 57°; Kieserite and KCl above 72°. According to experiment 72° is the highest temperature which could have prevailed at the time the salt beds were formed. A salt sea evaporating by ordinary summer heat assumes this temperature.

Hydrogen Peroxide.

Prof. Walter Nernst spoke on the formation of hydrogen peroxide at high temperatures. The question is, whether H_2O_2 is formed from steam + O_2 at high temperatures. No trace of H_2O_2 can be found in a mixture of the gases through which electric sparks have been passed. The reason for this is probably that the H_2O_2 if really formed by the sparks, is too rapidly decomposed in the moment in which it leaves the hot spark gap. If this is correct it must be possible to obtain H_2O_2 by cooling the products of the reaction very suddenly.

Nernst showed that H_2O_2 can be obtained by directing an oxyhydrogen flame against the surface of a vessel of water, or by producing electric sparks under water. It remained to be shown that the velocity of decomposition of H_2O_2 is very great. To determine the decomposition velocity of H_2O_2, Nernst passed a current of air through a solution of H_2O_2, and then heated the mixture of air + H_2O_2, at a fixed temperature, for a definite length of time in a glass tube of definite dimensions. The velocity of decomposition is about as great as that of ozone. The reaction is bimolecular, the decomposition takes place in accordance with the equation: $2H_2O_2 = 2H_2O + O_2$.

From the quality of the decomposition velocities of H_2O_2 and O_3, and from the fact that, in the gas, electric sparks produce the latter, but not the former, it must be concluded that O_3 is formed by ultraviolet light, which is radiated from the electric sparks, and that ultraviolet light does not form H_2O_2. Both gases, H_2O_2 and O_2 are formed under the influence of heat. The gas which is formed by the spark decomposes on leaving the vicinity of the spark.

Radioactivity.

Prof. C. Engler spoke on the radioactivity of the thermal springs in Baden-Baden. The speaker portrayed the geological origin of the radio-active springs of Baden-Baden, and described a method and a transportable apparatus which he used in his determination. The mud from the springs contains radioactivity in much greater mass than the water. The radio-active substances seem to be deposited with manganese peroxide, for the amount of manganese peroxide varies parallel with the amount of activity, though not proportional to it. The mud was analyzed. No thorium was found, although the decay curve is of the type characteristic of thorium emanation. It must therefore be assumed that a very strongly active new element is present. Radium also was found.

Tantalum.

Dr. Werner von Bolton presented a paper on tantalum and the Siemens & Halske tantalum lamp. Since we have already reported at some length on the author's work on pages 52 and 118 of our present volume, only new information shall be mentioned here. The speaker exhibited a regulus weighing 64 grams, in the smelting of which 75 hp. was required. This great amount of energy is the cause of the high price of the metal; the ore occurs quite frequently on the earth. The metal can be easily worked into very thin sheets and into fine wire (down to 0.03 diameter).

Interesting from an electrochemical standpoint is the ease with which it becomes passive. If 120 volts be applied to a cell of two tantalum electrodes in H_2SO_4 almost no current flows. But if one electrode be replaced by Pt only one half-wave of an alternating current can pass, *i. e.*, it can be used as a rectifier to convert alternating current into direct current. Glowing tantalum attacks water with the evolution of H_2 and violent combustion. Fine tantalum wires can be ignited with a match and burn in the air.

The speaker exhibited some tantalum lamps of 25 c.p. fed with an alternating current of 0.35 amp. at 110 volts. He heated his lamp to over 2000°, and obtained 350 c.p. with 0.3 watts per c.p. On raising the temperature the filament melted.

Physical Chemistry of Wine.

Prof. Th. Paul presented a paper on this subject. Up to the present time the volumetric method has been used for determining the amount of acid in wine. It is well known that the sour taste of wine does not depend on the total amount of acid contained, but on the concentration of hydrogen ions; a solution of weak acid is often not at all sour to the taste when a strong acid of the same concentration is decidedly unpleasant.

Wine is an alcoholic-aqueous solution of electrolytes and non-electrolytes, sulphuric acid, phosphoric acid, acetic, lactic, succinic and malic acid, glycerin, sugar, ester, tannin, dyes, etc. There are four methods for determining the concentration of H-ions: 1. Measurement of conductivity (on account of the great number of substances present this method does not give unequivocal results). 2. The application of hydrogen electrodes (it gives reliable results, but is too difficult for the wine dealer to manipulate). 3. The inversion of cane-sugar. 4. Catalysis of ethyl acetates. The last two methods, especially the inversion method, can be used very satisfactorily.

The speaker described an apparatus for measuring inversion. The determination was made at 76°, because at high temperatures it can be made more rapidly—the inversion constant is 0.0000097 at 25° and 0.00469 at 76°. Furthermore, one source of error is avoided, viz.: the ferments, which are always present in wine, also produce inversion. This ferment is killed at a temperature of 76°.

(To be Concluded.)

CORRESPONDENCE.

Genesis of Chemical Elements.

To the Editor of Electrochemical and Metallurgical Industry:

Sir: The editorial note on the subject of Genesis of Chemical Elements in your July issue, leads me to call attention to a brief article by Robert T. Hill, of United States Geological Survey, entitled "Source of Volcanic Water," which appeared in *Engineering and Mining Journal* of July 6 last.

It seems to me that the theories of Arrhenius and J. J. Thomson are related to a degree calling for a careful study of these theories, each as related to and affected by the other.

If the views of Arrhenius are found to be tenable and the earth's interior has a temperature more nearly the solar temperature than has hitherto been assumed, there are better reasons than ever for believing, not only that uranium, radium, polonium, helium and other elements are factors in atomic disintegration, but that a similar genetic relationship exists between all of the chemical elements, and that while marked radioactivity is shown by relatively few elements at present, an equal or greater radioactivity may have been shown in earlier stages of the earth's development by all of the elements of lower atomic weights, though they now appear to be entirely stable.

In conclusion, I add a copy of a note penciled on the margin of a work on chemistry nearly three years ago, after an apparently fruitless study of a table of "The Periodic System of the Elements":

"All 'elements' alike (*no elements*); when matter is in a condition, so to speak, of *a solid gas*, reached by sufficient simultaneous heat and pressure. Gravity is the one problem."

Roanoke, Va. Horace M. Engle.

Labor-Saving Appliances in the Baltimore Laboratory of the Anaconda Copper Mining Company.

In a most interesting paper recently presented before the American Institute of Mining Engineers, Dr. EDWARD KELLER points out that the ruling principle in shop and factory, *i. e.*, to secure the greatest output at least cost by the substitution of machinery for manual labor, has had little effect on the chemical laboratory in our industrial establishments. There the methods of analytical work have been carried on along individual traditional lines. Long series of filtrations and stirring are still performed singly by hand in a slow and laborious manner. As a rule, the chemist wastes much time by such manual labor, which, in a modern establishment and under up-to-date management, could be more advantageously applied to useful chemical work; and such higher chemical work is gradually and surely becoming recognized as an essential extension of old-time methods of assaying. While it may be said that in some laboratories, boys and not chemists, do the manual labor, it should be borne in mind that all chemical work requires care and accuracy, and in these respects boys are naturally a source of concern to the responsible chemist. Moreover, the cheapness of child-labor is largely offset by the increase in the expense account of laboratory materials, caused chiefly by breakages resulting from carelessness.

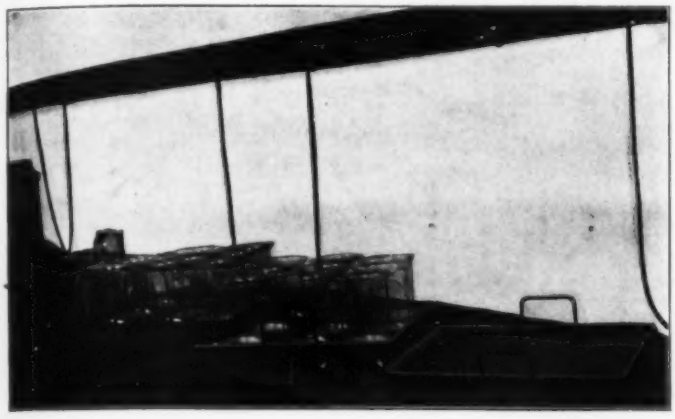


FIG. 1.—METALLIC TRAYS HOLDING NINE NO. 5 GRIFFIN BEAKERS.

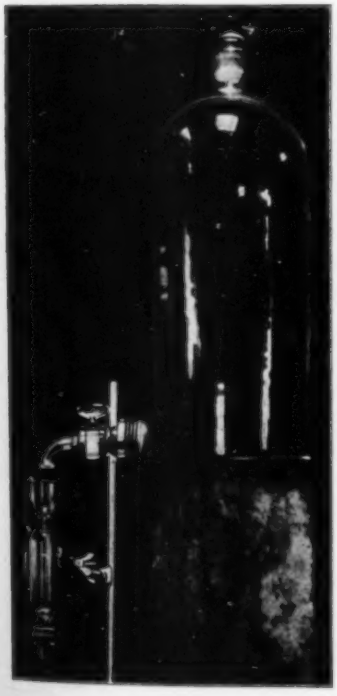


FIG. 2.—CYLINDER FOR MEASURING ACID.

On the basis of such considerations, Dr. Edward Keller, when authorized by the Anaconda Copper Mining Company to build a new laboratory in Baltimore, Md., decided to make its equipment superior to any that exists in this country or abroad. For this purpose he devised a great many labor-saving appliances. Their introduction has resulted in economy in several ways. Much labor has been saved; breakage of expensive glassware has been very largely eliminated, and the time of the furnace work, and, consequently, the consumption of gas, have been much reduced. Furthermore, the gain has been a moral one, and work formerly regarded as tedious has become more of a pleasure; especially has the sojourn in the furnace room during the hot summer months been rendered cooler by being greatly shortened.

These labor-saving appliances of Keller may eliminate the laboratory boy, but if not, they will make him more reliable. They also increase enormously the quantity of chemical work that one man can do in a day. In the domain of his own laboratory the change from the old systems to the new is considered to bear about the same relation as the change from ancient horse-car to the modern rapid transit.

A fully illustrated description of these labor-saving devices will undoubtedly be of great interest to our readers. For the permission to publish these extracts of Dr. Keller's paper we are obliged to the Council of the American Institute of Mining Engineers.

GENERAL ARRANGEMENT.

In such a carefully planned laboratory as this the general arrangement is, of course, a most systematic one; the ruling principle was to design it so that the number of movements required from the beginning to the end of every operation is reduced to a minimum.

The hygienic arrangements of the room were given proper attention, especially the ventilation, which, as a rule, is only made satisfactory by the proper construction of the hoods. At the Baltimore works-laboratory the two-compartment hood, built of brick, is plastered inside, has a tile floor, the openings into the laboratory being supplied with vertical sliding glass doors. The stack, 21 feet high, is directly over the slate roof of the hood, which tapers from two sides toward the openings of the stack. The cross-section of the openings from the hood to the stack equals that of the free space in the stack. The hood is built against the wall of the building, and parallel to this wall is a second one, leaving a free space of 4 inches between them, which communicates with the hood by a number of 2 x 4-inch holes along the floor, and with the stack by a larger opening at the highest point of the hood. This construction gives a good draught along the floor, as well as at the apex of the

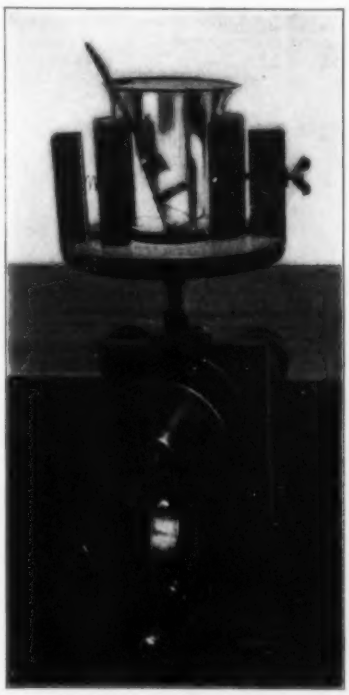
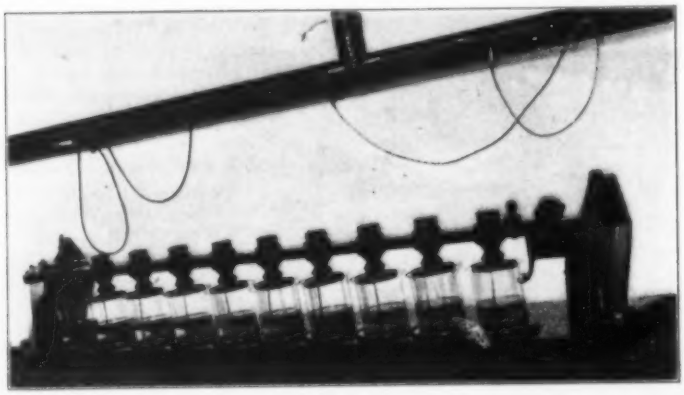
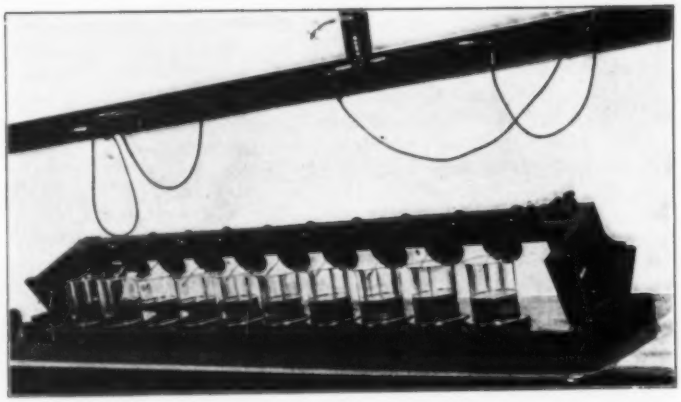


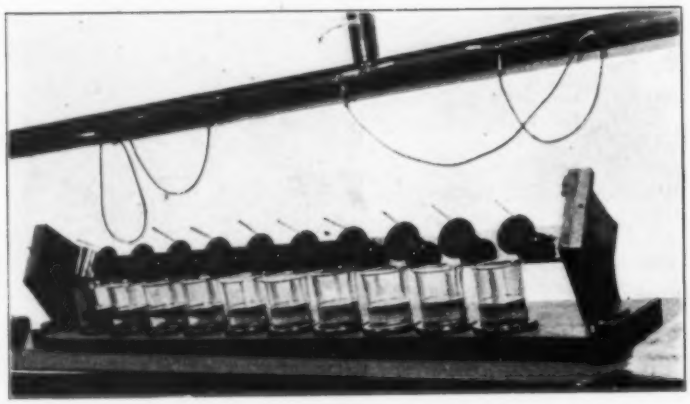
FIG. 9.—THE "POLICEMAN" IN BEAKER IN ROTATING MACHINE.

hood, and, regardless of the amount of copper that is being dissolved with nitric acid, there is never any noxious odor of "red fumes" in the work room of our laboratory.

With regard to cleanliness of work in the laboratory, Dr. Keller quotes his first teacher in practical chemistry, Hermann von Fehling, who used to tell his students that *Der Chemiker muss im Frack-Anzug arbeiten koennen.* "This remark made







FIGS. 3, 4, 5.—THE STIRRING MACHINE.

a lasting impression upon me, and I have always disliked the sight of black or yellow hands, or of work-clothes having many spots and holes. It is not given to everyone, however, to be as tidy as Fehling was, but it is possible to aid natural defects by artificial means."

Conveniences for Handling Beakers and Acids.

Assaying forms the bulk of the work at the Baltimore laboratory. Scores of silver-determinations and hundreds of scorifications and cupellations for gold are often made. Silver, and sometimes gold, is determined in the metallic copper material by what is commonly known as the combination method, which consists in dissolving both copper and the contained silver in nitric acid, leaving the gold as a metallic residue. The silver is reprecipitated in the form of chloride and, with the gold, is separated from the copper solution by filtration. The incineration of the filter, scorification with metallic lead, and cupellation with a subsequent parting of the two precious metals, completes the assay.

Keller has simplified this operation first by the introduction of metallic trays to hold the No. 5 Griffin beakers, thus avoiding handling them either singly or in pairs. The trays, shown in Fig. 1, hold nine beakers, and as soon as the copper has been dissolved the tray may be placed directly on the fire in order to expel the nitrous fumes by boiling the solutions.

The acid used to dissolve the copper is kept in a 5-gallon bottle, having a glass cock, or spigot, with an 0.25-inch orifice, through which the outflow is very rapid. From this bottle the acid is tapped into a specially designed measuring cylinder, shown in Fig. 2, provided with a stop-cock similar to that of the bottle, which allows the acid to be tapped into the beakers, without dripping, in a neater and cleaner manner than can be done by pouring from a bottle, beaker or cylinder.

After the copper solutions have become cold and the proper quantity of sodium chloride requisite to precipitate all the silver has been added, it is absolutely necessary to stir the mixture in order that the reaction shall take place throughout, and that, after adequate settling, none of the silver chloride will run through the paper during the subsequent filtration. The stirring of a large number of solutions by hand occupies much time and is very tedious, but omitted, the determination becomes faulty. Figs. 3, 4 and 5 illustrate a stirring machine which obviates all the difficulties incident to the manual operation of stirring, and, by its use ten solutions can be stirred in the same length of time occupied in stirring one by hand, and there is no splashing of solution or breakage of beakers.

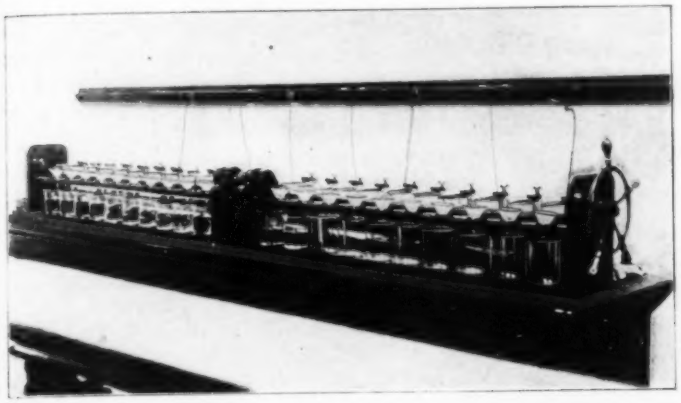
Fig. 3 shows the machine ready for use; Fig. 4 shows the position after the stirring-rods have been lifted from the solutions and are ready to be rinsed; and Fig. 5, the position assumed after the rods have been rubbed off, the discs holding them and forming a cover to the beakers, now being ready to be washed. This latter operation, however, is generally superfluous, for very seldom does any of the solution reach the covers.

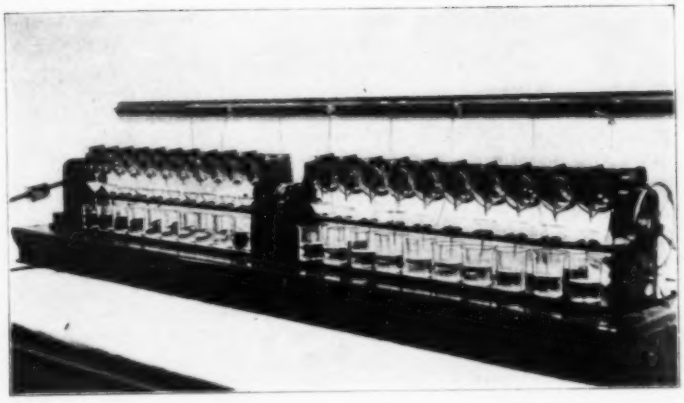
The characteristics of this stirring-machine are the three-based feet, the convenient driving-gear on the right which admits of the ready application of the mechanical powers; the slack take-up for the belt on the left, and the rubber discs which hold the rods and form covers to the beakers. The action of the machine is made universal by having several holes in each disc so that the position of the rods will conform to any size of beaker. The separate construction of both beaker-stand and stirring-stand permits a ready change of a set of beakers and allows the rods to remain a permanent part of the whole.

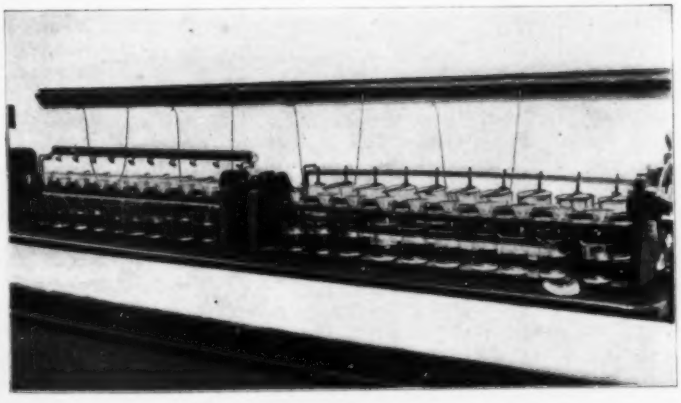
Filtering Apparatus.

The construction and operation of Keller's filtering or de-

canting apparatus are illustrated in Figs. 6, 7 and 8; and by its use twenty filtrations can be performed with perfect ease, and without the least danger of loss by splashing or breakage. The beaker-rack is tilted by means of a hand-wheel on the right, retrograde motion being prevented by a ratchet. The point of rotation of the whole series of beakers lies some distance from their lips, about at the end of the glass rods that guide the stream of liquid to a definite point in the filter, an arrangement which is essential for steady pouring. The lifting of the load is aided by a counterpoise on the left.







FIGS. 6, 7, 8.—THE FILTERING OR DECANTING APPARATUS.

By the use of this apparatus the filtering can be done leisurely with one hand, so steadily that the precipitate remains undisturbed until all the clear liquid is poured off, and the time of the whole operation is greatly shortened.

Figs. 6 and 7 show the machine as originally constructed, with a locking-device for each beaker and rod, consisting of an arm pressed downward by a spring, and free to rotate vertically within an angle sufficient to clamp, as well as to allow it to sweep horizontally over the rod and beaker, the horizontal rotation also being entirely free. Fig. 8 presents a locking device on the same machine by means of which ten beakers and rods are locked simultaneously. It is a matter of taste which arrangement is the more satisfactory. The beaker-rack and the filter-stand are adjustable to several sizes of beakers and funnels, and the machine can be made for any number of beakers. Light wooden trays are provided to carry the beakers, in sets of ten, to or from the apparatus.

Table I, containing the results of a test recorded by one of Keller's assistants, shows the difference in time between the new method of mechanical filtration and the old method by hand. The quantity of solution contained in each beaker varied between 275 and 300 c. c.

TABLE I.—COMPARISON OF RESULTS OF MACHINE FILTRATION VS. HAND FILTRATION.

	Machine Filtration.	Time Consumed. Minutes.
10.21 a. m.	Started.	
10.22 a. m.	Placed rods	1
10.30 a. m.	Finished decanting	8
10.41 a. m.	Washed beakers and rods	11
10.45 a. m.	Washed filters	4
10.55 a. m.	Rubbed out beakers	10
10.59 a. m.	Folded filters and placed in scorifiers	4
	Total	38

	Hand Filtration.	Time Consumed. Minutes.
11.13 a. m.	Started.	
11.14 a. m.	Placed rods	1
11.38 a. m.	Finished decanting	24
11.58 a. m.	Washed beakers and rods	20
12.04 p. m.	Washed filters	6
12.13 p. m.	Rubbed out beakers	9
12.17 p. m.	Folded filters and placed in scorifiers	4
	Total	64

Difference in favor of machine 26 minutes.

Keller decanted ten beakers, each containing from 275 to 300 c. c. of solution, in 4 minutes 30 seconds, the solutions being run through a double S. & S., No. 597, 12.5 cm. filter.

In connection with the work as just described, Keller entirely dispensed with the well-known wash-bottle, on account of the unnecessary physical strain involved in its use, as well as its unsanitary character in many instances. The distilled water contained in carboys, placed about 4.5 feet above the floor level, is siphoned into a system of glass tubing, extending throughout the laboratory wherever the water may be needed. This glass tubing is provided with numerous T connections, to which are attached rubber tubes, having pinch-cocks and glass nozzles at their ends, which permit the direction of a stream of water to any desired point. The water in the overhead carboys is replenished by forcing a new supply from another carboy in which it has been condensed, placed on a carriage on the floor, up through a glass siphon by means of compressed air.

When the filtration is complete and the precipitates have been washed out of the beakers, the latter must be rubbed out with paper in order to be sure that neither silver chloride

nor gold is retained on the walls of the vessels, perhaps by a little oil often contained in the samples, or by the drying and hardening of small particles of chloride above the surface of the solution. In order to facilitate this cleaning, Keller has designed a machine in which the beakers are rotated.

This machine is on rollers, and runs on rails fastened to the table in front of the filtering apparatus, and may be locked at any desired point. The rubbing is done by means of a "policeman," Fig. 9, which consists of a rod having a cork fastened at one end, over which is clamped a piece of filter paper, held in place by a conically-cut ring. The paper thus fastened is run along the bottom and side of the rotating beaker. For each beaker a fresh piece of paper is quickly clamped to the cork.

New assay furnace tools designed by Dr. Keller for his laboratory will be described and illustrated in our next issue.

Action of Acids on Iron and the Use of the Acid Pickle.

By Charles F. Burgess.

Definite knowledge, both quantitative and qualitative, on the subject of the corrosion of iron by the common acids, is of great usefulness, alike to the scientist and to the technical man. Yet it must be acknowledged that information relative to the action of acids on iron and its alloys is notably deficient, notwithstanding the fact that for a century or more it has been a subject of constant study, and that many investigators have given, and are still giving, their attention to it. To the investigator, who as an incentive needs a hope of practical utility rewarding his research, a study of this subject offers much that is attractive. That results of scientific as well as of practical value may arise from it is shown by the insight which has been given recently into the constitution and properties of iron and its alloys, through a knowledge of the action of acids upon the various constituents of commercial iron and steel.

To one who has never given the subject any especial thought it might appear that to determine the rate of the corrosion of iron by hydrochloric, sulphuric or nitric acid, and to note the effect that each exerts upon the iron, would be a simple matter enough, and he might feel some surprise that the subject has not been thoroughly investigated long before this. Study will show him, first of all, that scattered throughout scientific and technical literature there is an abundance of material coming from many valuable sources, which might possibly be so collated and classified as to place all needed information in a useful form. He would soon find, however, that such literature abounds in the most conflicting statements—that, for instance, one authority will claim for hydrochloric acid a more rapid action on iron than he is willing to accord to sulphuric acid, while another will ascribe a greater activity to sulphuric acid. He will see, too, that while many qualitative results are given, comparatively little quantitative work is recorded, while between the quantitative results that are given by different investigators there is but little agreement.

This condition of affairs may be ascribed to several causes. Differences in the degree of care exercised by various observers can account only in small part for such glaring inconsistencies of statement. It has been commonly assumed that hydrochloric acid is hydrochloric acid the world over, and that wrought iron is the same material wherever it is found. It is to such assumptions that many of these discrepancies are due. The assertion that a 10 per cent solution of hydrochloric acid will dissolve ten grams per hour from a square foot of wrought iron actually means little more than that from wrought iron in general a certain amount of corrosion takes place which can be readily detected. To make such a statement of any real value we should be given the temperature, the number and the amount of impurities in the acid solution and the chemical and physical constitution of the iron which has been thus treated.

When from available literature we exclude such data as this on the ground of its incompleteness there remains comparatively little that is suitable for use. On the other hand, to furnish all the desired data involves an expensive and laborious investigation that few are able or willing to undertake, while even when the results are given, so many variable factors are involved that to draw general conclusions and to deduce general laws from a number of investigations becomes a most complicated matter. This might lead to a question as to whether the importance of the matter would justify such research, but reference need only be made to the various industries in which the corrosion of iron is an economic factor to allay any doubts upon that head.

Prevention of Corrosion.

As it is the most important structural material in use at the present time, iron is necessarily frequently used under conditions giving opportunity for acids and other corrosive liquids to make contact with it. This is only an exaggerated example of the corrosion to which steam boilers, structural iron work, underground piping and the like are subjected. Iron is employed in the chemical industries for piping, storing and conveying acids, iron tank cars being used extensively for the last-named purpose. In the design of such structures, consequently, the corrosive factors must be taken into consideration, this being necessary for the sake of both safety and economy. Knowledge of these factors will direct that iron shall be used for certain acids, but rejected for others. Also, since it is known that some grades of iron are more resistant to the corrosive effects of certain acids than are other grades, it is important to ascertain which are the most durable grades. It also is often possible to introduce certain impurities into the acid, which will still farther enhance the durability of the iron containing-vessel. Thus it will be seen that definite knowledge as to the influence exerted by such impurities is highly desirable.

Acid Pickles.

While the prevention of corrosion is a matter of economic importance in certain lines of work, for other purposes it is equally important that the action of the acid should be facilitated.

The term "pickle," as used in the metal-working industries, is applied to acid solutions into which a metal article is dipped to free its surface of oxide, scale or crust, or to give it a rough or matt appearance. While such dip is used in connection with the treatment of copper, brass, steel, iron and many other metals, it finds its most important application in the iron and steel industry, and it is with reference to this branch of the work that the following will have principally to deal.

Pickling constitutes an essential step in the well-known galvanizing process. Prior to immersing the sheet metal in the molten zinc it must be freed from scale and other oxides, and this is most satisfactorily accomplished by the use of the acid dip. To show something of the magnitude of this one operation alone, it may be estimated that since 60,000 tons of zinc per annum are used in this country for galvanizing, the area of surface which is thus protected is approximately equivalent to 70 square miles, or 40,000 acres. The area which must be pickled in the manufacture of wire and sheet metal probably largely exceeds even this. Statistics given in *The Mineral Industry* for 1903 show that about 1,500,000 tons of iron wire were produced during that year. Such an amount of iron in the form of wire possesses over 100 square miles of area, and since the process of pickling must be repeated several times during the operation of drawing, the pickled area is unquestionably larger than this amount. From figures taken from the United States Census Report for 1900 about 20,000,000 pounds of tin were used that year for the production of tinned sheets, and this again represents a second area of about 140 square miles which must be pickled, not once, but twice.

In the process of wire drawing, rods about two-tenths of an inch in diameter are drawn through a series of round, tapering

holes in a die, each hole being smaller in diameter than the preceding one. Prior to passing the rod received from the rolling mill through these dies, it must be pickled, to remove any scale which would otherwise rapidly cut the die. After passing through a number of dies, varying from two to six times, according to the quality of the iron being drawn, and the amount of reduction required, the metal becomes hard and brittle and annealing is necessary. This is accomplished by raising the iron to a red heat, and allowing the temperature to fall slowly. In this process another scale forms on the iron, and a second pickling operation becomes necessary.

The manufacture of iron stampings and cold-rolled ware likewise involves repeated annealing and pickling of the product. In the production of enameled ware, enormous quantities of which are manufactured annually in the United States, the acid corrosion constitutes an important step in the operation, since the scale must be removed before the article is stamped into shape and again after it has been annealed, that it may present a perfectly clean surface for reception of the enamel.

Pickling is also used by the electroplater in preparing his work to receive its nickel or copper coating, and it is likewise necessary for structural iron prior to painting, lacquering or varnishing of the metal surface. Many other applications of the process could be cited, but these given are sufficient to show that the action of acids on iron surfaces ranks among the most important problems with which the modern engineer has to deal.

In spite of the fact that this operation is by no means a modern one, and that those who use it form a numerous class of workers, no uniformity of practice seems to have been evolved. Each operator has a method of treatment peculiarly his own, the outgrowth of his personal experience and rule-of-thumb trials rather than of any general principles that have gained recognition. One operator will use hydrochloric acid, another will prefer sulphuric, and a third will cling to certain mixtures. Not infrequently do metal-plating establishments receive visits from an "expert," whose garb testifies to the material prosperity of the wearer, and who offers for a certain bonus to divulge a secret formula by which the pickling department may double its output through the elimination of certain difficulties which thitherto had proved unsurmountable. Strange and wonderful are many of the recipes thus procured. One such which has been brought to the attention of the writer produced a pickle, that when first set up, undeniably proved to be most active, but for what purpose the majority of its dozen or more ingredients had been added was difficult to explain. Especially did the requirement of 2 per cent of whiskey add to the mystery!

An ideal pickle for removing scale and rust would be one which would remove the coating without attacking the underlying metal. To this end the acids must be so chosen as to exert a maximum solvent action on the oxide and a minimum solvent action on the iron.

According to Comey (Dictionary of Chemical Solubilities) iron is readily soluble in most acids, particularly so in sulphuric and hydrochloric; nitric acid also exerts great solvent action, unless in such degree of concentration as to render the iron passive. The rate of corrosion of acids varies with the concentration, increasing as the concentration increases up to a certain limit, after which the rate of corrosion decreases. This variation is sometimes very irregular. The temperature also has a marked effect, the activity of the acid increasing with the higher temperatures. This furnishes a reason for the common practice of heating pickling solutions. The increase of acid efficiency produced by heating is not uniform for all grades of iron, it being claimed that for charcoal pig and case-hardened cast iron the increased rapidity of attack by boiling acids is less than for certain other grades of iron. The addition of soluble salts of copper, platinum and certain other metals greatly increases the action of an acid, while the addition of arsenic, it is claimed, almost entirely prevents the action of sulphuric and hydrochloric acid on iron.

According to the same authority, the principal iron oxides to be considered are ferrous oxide, FeO; ferric oxide, Fe_2O_3, and ferroferric oxide, to which is assigned the formula Fe_3O_4. Ferrous oxide is easily soluble in hydrochloric and nitric acids, but nearly insoluble in sulphuric acid, even when heated. This oxide is, however, of minor import. Ferric oxide, an example of which is the ordinary brown rust, is attacked by acids with difficulty, the more so the higher it has been heated. Aqueous hydrochloric acid solutions when heated are given by Fresenius as the best solvents for this oxide, while Mitscherlich claims it is most easily soluble in eight parts of sulphuric acid to three parts of water. By far the most important oxide with which the pickler has to deal is the black, or magnetic oxide, to which the definite formula Fe_3O_4 is commonly ascribed, but which is sometimes considered as being a mixture of FeO and Fe_2O_3. The only solvent which Comey gives for this oxide is hydrochloric acid.

It will be seen that the oxides of iron are much more resistant to the action of acids than is the iron itself, so that the principal desideratum of an ideal pickle cannot be attained through their use. To remove the oxide we must depend, to a large extent, upon the action of the acid on the metal which underlies the oxide, thereby loosening it so that it falls off or is left readily removable by physical means.

The black oxide, which is always formed when iron is heated in the presence of air or other oxidizing agents, presents various physical characteristics determined by the degree of heating, the length of time and the properties of the underlying metal. It may form, under some circumstances, a thin, film-like and strongly-adhering coating, and in other cases it may create thick scales which can be detached by hammering, rolling or other mechanical means. While this coating usually presents a continuous appearance to the naked eye, when carefully examined under the microscope it will be found to be perforated by cracks or holes through which the acid can enter. The iron in contact with such scale is more readily attacked by the acid than when the surface is entirely clean, since the black oxide is electronegative to the iron and sets up active electrochemical couples.

PRACTICE IN PICKLING.

It must not be inferred from what has been stated previously that iron and steel manufacturers have not given extensive and systematic study to the matter of utilizing acids to their highest efficiency. In this country the leading producers of wire, sheet metal and structural iron have worked out economies in this detail of manufacture as well as in other steps of their processes, and have thereby led the world in cheapness of production. There has been continual and careful comparison of acid consumption and methods, and through modifications of the operation, necessitated by changes in the treatment of the steel previous to its pickling, the quantity of acid required has been reduced materially, and this, in turn, has led to a saving in the metal itself, since the consumption of an acid means the consumption of a chemically equivalent amount of iron. This detail in manufacture has not, however, been the subject of wide discussion before engineering societies, nor has it been given the same degree of publicity accorded other features of the manufacturing processes.

Choosing at random information to be found in various technical books and publications, we can readily see the differences in practice which prevail among the various users of the pickling operation.

In describing the Cowper-Cowles process of electrogalvanizing (ELECTROCHEMICAL INDUSTRY, March, 1903, p. 263), it is stated that the removal of mill scale from forgings and plates has always been a matter attended with much difficulty. The pickle recommended is one part sulphuric or hydrochloric acid to ten parts of water, the period of immersion ranging from one-half hour to twenty hours. It is asserted that the British admiralty specifies that all steam pipes, boiler and collector tubes and all plates for boilers shall be pickled in a liquid con-

taining one-part hydrochloric acid to nineteen parts of water until all flack oxide is removed.

According to Marks (*The Manufacture of Iron and Steel Tubes*) the process to be used involves the employment of a weak acid solution, consisting of one part hydrochloric acid to thirty-nine parts of water. Brannt (*Metal Workers' Handybook*) asserts that for cast iron and wrought iron articles a mixture of one part sulphuric or hydrochloric acid and ten parts of water, to which some tar has been added, should be used.

Randau in his work on "Enamels and Enameling" says that the usual strength of acid pickle is one part of commercial sulphuric acid to twenty to twenty-two parts of water, the time of immersion depending upon the strength of the pickle. If the exposure is not to be more than from ten to twelve hours a stronger pickle is used, and, as a rule, the ware should not be allowed to remain in the pickle for more than twenty-four hours. When the ware is left too long in a pickling liquid that has been in use for some time, and has, consequently, taken a relatively large amount of iron into solution, the liquor forms, in the presence of iron, certain insoluble basic salts which adhere firmly to the metal in the form of a soft powder, thus defeating the very object of the pickle. Such "overpickled" goods must then be scoured with sharp sand and pickled afresh. The solution should be operated at a temperature of from 20° to 40° C.

Sabin (*Technology of Paint and Varnish*) discusses the practice followed both in the United States and abroad relative to the removal of mill scale from structural iron prior to painting. The pieces are immersed in hot dilute sulphuric acid of a strength of from 25 to 28 per cent, some factories employing a 20 per cent solution. To completely remove rust and scale will take from six to twelve minutes. Combinations of rust and scale are much more readily removed than the adherent blue or irridescent rolled scale alone. Where only the hydrated oxide is to be removed this is readily dissolved in a 10 to 12 per cent acid. He states that in Germany it is customary to use a 9 or 10 per cent acid, cold, leaving the metal in solution for five hours, but that this requires a larger plant and offers no especial advantages. In subsequently washing the article by dipping it into water the iron becomes coated with a gummy or collodial substance, the exact nature of which is not known but which is very difficult to remove. To prevent the adherence of this substance it is recommended that the washing should be effected by using a jet of water, which removes the material as rapidly as it forms. It has been suggested that this trouble may be due to the presence of arsenic in the solution, and for this reason many picklers in purchasing acid specify that it shall be free from arsenic.

He also states that it is often difficult, and sometimes quite impracticable, to pickle steel high in carbon or cast iron containing graphitic carbon, on account of the deposition of a film

TABLE SHOWING VARIETY OF PRACTICE IN THE OPERATION OF PICKLING SOLUTIONS FOR IRON

Material Treated.	Purpose.	Composition of Pickle.	Time.	Reference.
Drawn iron and steel tubes.	Removal of mill scale after annealing.	1 part HCl–39 parts water.	.....	Marks.—"The Manufacture of Steel and Steel Tubes."
Cast or wrought iron articles.	Removal of scale.	1 part HCl or H_2SO_4 to 10 of water, to which tar is also added.	.....	Brannt.—"Metal Worker's Handibook."
Iron ware.	Preparatory to enamelling.	1 part of H_2SO_4 and 20 to 22 parts of water. 30° to 40° C.	Under 24 hours.	Randau.—"Enamels and Enamelling."
Structural iron.	Removal of scale and rust.	25% to 28% H_2SO_4 hot, or 9% to 10% H_2SO_4 cold.	6 to 12 minutes. 5 hours.	Sabin.—"Technology of Paint and Varnish."
Sheet iron.	For galvanizing.	HCl preferable to H_2SO_4. 1 part acid to 1 part water.	.....	Harbord.—"Metallurgy of Steel."
Sheet iron.	For tinning (preliminary operation).	Commercial H_2SO_4, 1.6 to 1.74 s.g. diluted by equal amount of water.	.....	Harbord.—"Metallurgy of Steel."
	(After rolling and annealing.)	Weak solution of H_2SO_4 free from arsenic.	.....	Harbord.—"Metallurgy of Steel."
Structural iron.	Removal of mill scale for electro galvanizing.	1 part H_2SO_4 to 10 water, or 1 part HCl to 10 water.	5 to 20 hours.	Cowper-Cowles.—"Electrochemical Industry" March, 1903, p. 263, British Admiralty specification. Ibid.
Boiler plates, tubes and steam pipes.	Removal of scale for inspection.	1 part HCl to 19 water.		
Rough castings and wrought iron.	For electroplating.	1 part H_2SO_4 to 4 water.	.....	Hawkins.—"The Polishing and Plating of Metals."
Smooth castings and stampings.	For electroplating.	1 part H_2SO_4 to 10 water.	.....	Hawkins.—"The Polishing and Plating of Metals."
Castings with adhering sand.	For electroplating.	1 part HF to 15 water.	.....	Hawkins.—"The Polishing and Plating of Metals."
Iron and steel.	For removing rust.	Pure concentrated HCl.	4 to 20 minutes.	Hawkins.—"The Polishing and Plating of Metals."
Sheet iron.	For galvanizing.	1% H_2SO_4 solution.	6 to 8 hours.	Molesworth.—"Pocket Book for Engineers."
Wrought iron.	For electro-galvanizing.	HCl preferable to H_2SO_4 except for cost.	.....	Davies.—"Galvanized Iron."
		H_2SO_4 of 1.85 s.g. diluted by 5 parts water.	20 minutes.	
		HCl of 35° Twaddell diluted by 1 water.	12 to 15 minutes.	
Wrought iron.	For electroplating.	2% HNO_3 or 8% H_2SO_4 or 2% HCl.	.....	Foster.—"Electrical Engineers Pocket Book."
Cast iron.	For electroplating.	3% HNO_3 or 12% H_2SO_4 or 3% HCl.		

of carbon, like stove blacking, on the surface. Hydrochloric acid has been used instead of sulphuric, but it is not well suited to the purpose, being more expensive to procure and more difficult to remove. It also forms a gummy substance on the iron, which is worse than that produced by the use of sulphuric acid, and in the subsequent alkaline treatment it must be neutralized with caustic soda instead of with lime. After the iron has been freed from sulphuric acid by washing it with a jet of water, it is put into a bath of lime water or milk of lime made boiling hot—a matter of great importance—and left there long enough for the metal to reach the temperature of the surrounding liquid. It is then removed to an oven and dried, after which the lime is brushed off. If desired the lime may be removed before putting the iron into the oven. In this case it will be found that the surface, which is perfectly clean and bright, rusts easily and quickly, whereas if the lime is removed by drying and brushing the surface it is less likely to rust. Even then, however, it rusts easily and should be painted immediately.

Sabin says that some of the largest work done recently has been treated in the following manner: The steel from the mill was put into a hot 10 per cent caustic soda solution until all the grease and oil came off, together with dirt and a certain amount of scale, making a bulky sludge. Next, the steel was washed in boiling water and put into a hot solution of sulphuric acid of 10 per cent strength, and left until the metal surface was completely exposed, after which it was dipped into boiling water, then into a hot 10 per cent solution of carbonated soda, well washed and finally dried in the oven.

Harbord and Hall (*Metallurgy of Steel*) say that where readily obtainable hydrochloric acid is preferable to sulphuric in the proportion of one part of acid to one part of water, since it does not require warming, and the sheets previous to galvanizing do not require to be soaked in water but may be passed at once to the molten zinc bath after only a moment's drainage. The cost of pickling by either acid is stated to be about the same, the difference in the quantity required being equalized by the difference in price, but hydrochloric acid has the advantage of being quicker in its action and generating fumes which are less objectionable to the workmen.

It appears from this same work that the practice followed in the preparation of sheet iron for tinning is different from that used for galvanizing. The black iron is first subjected to what is known as the black pickle, in which sulphuric acid made from pyrites is used, the acid having a specific gravity of from 1.6 to 1.74 and being diluted with an equal amount of water. The sheets coming from this bath are washed in water and annealed and then rolled to give a smooth surface. They are then pickled again in a weak solution of sulphuric acid, made from burning sulphur to render it free from arsenic, which would leave black streaks on the plates.

In the electroplating industry, even a larger number of problems arise in connection with the pickling process than in the industries heretofore cited, this being due to the greater variety in the kinds of iron which must be treated. A distinction is made ordinarily between dips and pickles, the first named usually consisting of undiluted acids or mixtures of acids, the purpose being to dissolve the coating substances while leaving the underlying metal smooth and unattacked. Pickles, on the other hand, are diluted acid solutions designed to corrode the metal. Hawkins, in his work entitled "The Polishing and Plating of Metals," which is a thoroughly practical account of the electroplating processes used in this country, recommends the following solutions:

Dip for Iron.—For removing rust from iron or steel goods of any kind a dip of pure muriatic acid is used. Where the goods are not very rusty four or five minutes' immersion will be sufficient; if badly corroded, from ten to twelve minutes will be required; but this dip will remove the rust, no matter how thick, without hurting the metal if the work is removed and thoroughly rinsed, first, in cold then in hot water, and dried in sawdust as soon as the rust disappears.

Pickle for Iron.—For a quick-working pickle on rough iron castings use sulphuric acid in the proportion of one part acid to four parts water; for a slower acting pickle intended for smoother castings and stampings use one part sulphuric acid to ten parts of water. The amount of water may be increased still more in pickling very smooth pieces where little sand or scale is present. The pickle in every-day use for castings and wrought iron goods consists of one part acid to four parts of water. Generally it is used cold, but where large quantities of work are to be pickled and the saving of time is an object, the operation will be hastened if the pickle is kept at about 150° F.

Where castings contain silica and adhering sand, a hydrofluoric acid pickle is used to considerable advantage. For a strong and quick-acting solution, one part acid to fifteen parts of water is used, and for a slower-acting solution the quantity of water may be doubled.

(*To be Concluded.*)

A Furnace for Metallurgical Research.

By Woolsey McA. Johnson.

A furnace designed for use in a metallurgical laboratory should be capable of producing on a small scale as many as possible of the conditions of large scale work as regards temperature and character of flame. The operator should be able to control these conditions with ease and certainty. Moreover, the furnace should be durable. Any parts not durable, should be easily removable. Besides, the furnace must not take up too much valuable room in the laboratory.

An experimental furnace of mine located at Hartford, Conn., was described in the *Engineering and Mining Journal* of July 18, 1903. Shortly after that date I designed for the metallurgical research laboratory of the Lanyon Zinc Co., which department I organized, a furnace which, like the first furnace, was capable of being used for a variety of reactions. In actual practice this furnace was found to be durable, and easy to handle. The total cost was $175. The control of temperature can be seen by referring to the Electrochemical Industry, May, 1904, p. 185. Here it will be seen that we could hold temperature constant, or raise it about a degree a minute for a long time.

The fuel used was Kansas natural gas, consisting largely of methane. Consequently, unless special precautions are used, the gas has a short cutting flame. The ignition point is high, but combustion once started proceeds usually with great violence. Accordingly to conserve heat and carry the flame for some distance, the furnace was designed with 13½-inch walls, and with air spaces between these walls wherever possible. These air spaces were filled with mineral wool, whose melting point, acording to statements of manufacturers, was higher than temperatures expected, but in reality this wool was made from a very fusible slag. Probably the wool in these spaces was melted during the first day the furnace was really heated up.

But at all events, the thick walls with air spaces brought about the desired effect,—the flame when once the furnace was in operation could be carried a long distance without cooling the luminous particles of carbon. For, usually heating was effected by radiation of a luminous flame (the same principle as used in an open-hearth furnace) and not by "direct contact."

The air used in all cases for burning the gas was preheated, by passing through three retorts in series in the highest chamber, and finally through a flue 4½ inches by 22½ inches to the gas supply. These retorts were put in green, that is, dried, but not burnt in the kiln. The butts were knocked out so that they were practically fireclay pipes. They could easily be replaced by knocking out loose brick work at both ends of the furnace. Small "jack arches" in the wall above the retort permitted this. When slowly heated up and always

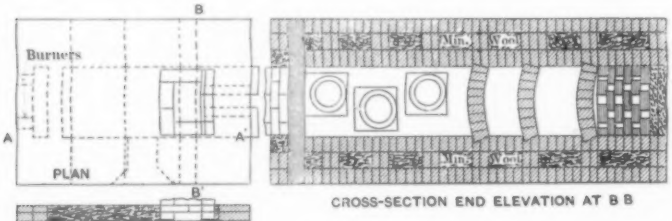
kept warm, (say above 300° C.), these retorts will last a very long time. But any sudden cooling down develops innumerable internal strains and cracks from these strains. Thus the whole body of the fireclay becomes rotten.

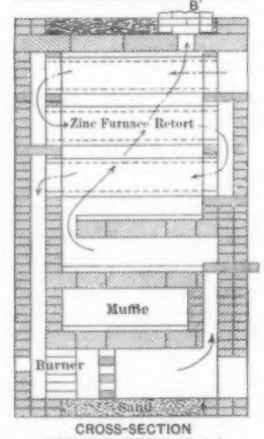
In about a year we put in two new sets of retorts in the preheater. The cost of a new retort being not over 50 cents, the repairs on preheater amounted to an insignificant sum.

At first the draft of the furnace was sufficient to give the furnace all the air necessary. But in time, the sum of all tiny leaks developed the reducted draft so that we put a 12-inch electric desk fan on a shelf outside the furnace and directed it at the opening of the preheater. By varying the voltage of the pan it was possible to regulate wind on furnace to a nicety. Pyrometer tests showed that it was possible to deliver air to the combustion chamber at a temperature of 1100° C., if desired. The gas amounting to about one-tenth the volume of air was not preheated, for it would have helped but little.

The gas came into the building at a pressure of 1½ pounds, and was fairly constant in pressure.

One large gate valve with a 10-inch sheet zinc dial, graduated in fractions of a circle on handle allowed accurate control of flow of gas. By use of two valves, one on each burner, it was possible to cut gas off without disturbing the position of regulating valve.





The burners were of the type called "jet-burners." They consisted of a T, fitted with two 1½-inch capped nipples. This all formed a large T, which was drilled with numerous 3-32-inch holes. These burners were set in the furnace with plastic fireclay, indicated in drawings. They could be easily replaced, but as set in a recess of brick and kept cooled by the flow of gas, they lasted for a year, and should last a much longer time.

The heated air was then mixed with these jets of gas. The air being hot, and the combustion chamber extremely hot, active combustion ensued and was helped by the mixing which the gases received as they passsed through checker work. The flame was then carried to the working chambers and used for the desired purpose.

The rate of combustion of coal and gas, and the character of flames are important and neglected parts of metallurgy. The checker work was first composed of firebrick made from good St. Louis clay. These were soon melted to a paste and were replaced by silica brick. The silica brick lasted until some sudden change of temperature "rotted" them.

The lower working chamber was about 30 inches by 22½ inches by 15 inches high to bottom of arch. The floor of the furnace was silica sand. This was an extremely wise provision, for it permitted any fusible material, such as charge spilled from the crucible to be pulled out and fresh dry sand put in.

From the lower working chamber the flame passed up a flue 22½ inches by 4 inches into the upper working chamber. By a proper manipulation of air and gas it was possible to produce any heat from 300° C. in this working chamber. Here we did all our work in reduction temperatures, volatility of silver in roasting, decomposition, temperature, etc. The lower working temperature was used almost exclusively for fusions.

In this, and in two small electric furnaces I repeated with much extension nearly all Percy's experiments on the metallurgy of zinc as well as many other experiments to test in the "try-it-and-see" way, many ideas that occurred to me while metallurgist of the No. 2 works of the Lanyon Zinc Co.—ideas that seemed likely to help us in our large scale work. These small experiments, if promising, would be carried out on 100 or 200 pounds of ore at the No. 2 works. I have never had a more perfect union between theory and practice. This happy result can be attributed in large measure to the fact that we had in this experimental furnace a first-class metallurgical instrument which allowed the experimenter to control conditions accurately.

Between the upper and lower chamber was a muffle chamber of about the same size. This was used for drying firebrick, crucibles, etc., etc. The door to every chamber consisted of a large block of fireclay. In several places were clamps to hold a Le Chatelier pyrometer tube, and circuits leading to the galvanometer placed on a brick pier near furnace.

Above the upper working chamber were set the three zinc retorts which served as preheater, as described before. The top of the furnace consisted of large firebrick plates covered with mineral wool. The stack rested on heavy iron bars exposed to air for cooling purposes. It was about 12 feet high above the furnace, for first half firebrick, then red brick. Inside dimensions, 8 inches by 8 inches. At each corner of stack were 2-inch angle-bars, tied every 4 feet in the usual manner of tieing chimneys. The furnace rested on a concrete foundation 20 inches wide, following the line of walls. Firebrick plates were used as dampers between upper and lower working chambers.

The "ironing" of the furnace was substantial and satisfactory. At each corner a heavy 4-inch angle-bar was set in brick work. Horizontal courses of 5 inch by ¾-inch flat steel bars were set in flush with face in brick work, one at the top of the furnace and one to take thrust of each of the three arches. There were thus four courses of these steel bars extending clear around the furnace. Four 40-pound old rails were set as buckstaves on the longer sides. The buckstaves were bedded in concrete at the bottom. Four sets of 1-inch round bars, each with eye, threaded end, nut and washers tied the furnaces horizontally. These are set just like tieing of a square chimney. They included the buckstaves. Upper expansion was neglected. The furnace developed few cracks after a year of many temperature changes.

The chief disadvantages of this furnace were inaccessibility of the lower chamber, for the operator was obliged to stoop to put in the crucibles, and the fact that it was hard to clean the upper chamber. But lack of space in the laboratory caused us to build vertically rather than extend horizontally.

In a later issue of this journal, a description of a serviceable electric crucible furnace will be given.

Huntington-Heberlein Process.—It is reported that the American Smelting & Refining Co. has decided to adopt this process, and that it has been put in operation successfully by the Sullivan Group Mining Co., Marysville, B. C. The process divides the roasting of PbS into two steps. First, in a reverberatory furnace a mixture of PbS with CaO is heated in a strongly oxidizing atmosphere to 700° C. Second, the product is cooled in a strongly oxidizing atmosphere to 500° C., and subjected to an air blast in a converter. This reaction develops sufficient heat to maintain the temperature; SO_2 escapes, and the product is PbO, $CaSO_4$ and gangue.

Paul L. T. Héroult.

Of European electrochemical and electrometallurgical engineers none is better known all over the world than Dr. Paul Héroult, the famous pioneer of the electrometallurgy of aluminium and steel. While France is proud to claim him as a Frenchman, the results of his work belong to the world.

Paul Louis Toussaint Héroult was born at Thury-Harcourt (Calvados, Normandy), on April 10, 1863. Since his grandfather lived in England he spent his youth's happy days partly in France and partly in England. He was educated at the Lyceum of Caën, Normandy, and later at St. Barbe, in Paris, where he graduated in 1882, to enter the Paris School of Mines (Ecole des Mines). From 1883 to the beginning of 1884 he served in the French army and then returned to the School of Mines, but on account of the death of his father he was soon forced to quit his studies in order to conduct the business of his father's tanning works.

However, Héroult continued there his metallurgical researches. He was specially interested in the electrochemical production of metals. He bought a small Gramme dynamo of 1.5 hp., which he replaced in 1886 by another small machine giving 800 amps. at 15 volts. This machine was specially built for his aluminium process, for which he had applied for patents in the same year. Héroult's revolutionary work and success in the aluminium industry is so well known to our readers that nothing further need be said here. In 1887 he became the technical manager of the Neuhausen aluminium works of the Swiss Metallurgical Co., where his process is in use up to the present. He then started an aluminium plant in France, at Froges, Isère, for the Societé Electrometallurgique Française. About the same time he made two trips to this country, where, meanwhile, independently of, and simultaneously with him, Charles M. Hall had worked out his aluminium process, and had started the works of the Pittsburgh Reduction Co.

After his return to France, Héroult assumed the management of the Froges works, but after the erection of a larger water-power plant in La Praz, Savoy, he became the general manager of these new works at La Praz, where he still resides. Dr. Héoult married Mademoiselle Chateau, and has five children.

To show what a broad man Héroult is, it may be mentioned that in the erection of the La Praz works he proved his ingenuity as a hydraulic and mechanical engineer, since he modified the original designs of the water pipe line over the Arc River, so as to diminish the first cost very materially. The designers wanted to erect a special bridge for the support of the pipe line, while Héroult found by mathematical calculations that it would be possible to construct the pipe line in form of an arc without any further support than the two pillars at both sides of the river. In 1892 the power developed at La Praz was 3000 hp., which was increased to 13,000 hp. in 1895.

Héroult's electric aluminium furnace, which by the addition of a tap hole was rendered a continuous apparatus, became in his hands the instrument for numerous further researches. In it he made the first commercial calcium carbide produced in France. In it he undertook, for the Societé Electrometallurgique de Froges, the manufacture of artificial corundum, ferrochrome and ferrosilicon, and thus he was led to his researches on the use of the electric furnace in the iron and steel industry, which is now in the foreground of interest. Héroult's work in this field has been so often described in these columns that it must suffice here to give references to these descriptions (our Vol. I., pp. 63, 287, 449, 467; Vol. II., pp. 408, 481; Vol. III., pp. 45, 155), and to state the fundamental principle, which is the production of an artificial slag above the fused bath, the carbon electrodes being suspended into the slag without reaching into the bath itself. In this refining furnace Héroult states that at a cost not exceeding 50 cents a ton, he can make out of any steel delivered in the molten state (*i. e.*, as tapped out of a Siemens furnace or a Bessemer converter, a metal of any desired composition containing less than 0.01 sulphur and 0.01 phosphorus. By operating this electric furnace in connection (not in competition) with existing open-hearth or Bessemer converter plants, Dr. Héroult predicts a revolution in the quality of the steel used for many industrial purposes.

The main point is that he has made steel on a commercial scale in his electric furnace, and has sold it in competition with crucible steel for nearly three years. His company's exhibit at the St. Louis World's Fair received the grand prize.

As another example of Dr. Héroult's versatility it may be mentioned that he is now also engaged in researches on a new system of navigation. The main idea is that at a very high speed the water will behave like a solid, and that it will require less power to skip, so to say, on the surface of the water than to plough through it. While this idea is already used to some extent in automobile boats, Dr. Héroult has devised special apparatus which very materially reduces the friction of the hull on the water.

But after all it is the man as a man that makes Dr. Héroult most attractive. His massive body gives an impression of immense latent energy, while in his direct and cordial manner he represents a most happy mixture of the best traits of the different nationalities among which he has lived. He speaks English and German as fluently as French and without any accent. In his courtesy and vivacity he is a typical Frenchman, while in his broad and well founded common sense in dealing with engineering problems he is like an American captain of industry.

There is one more point to be emphasized about Dr. Héroult as an engineer—that is his firm belief in the importance of theory. He once told the writer that wherever he was successful as an engineer, his success was based on previous theoretical analysis and calculation.

For ourselves we are glad to use this opportunity of acknowledging Dr. Héroult's friendship toward this journal from the very start. To our September issue, 1903, he contributed an article on his electric steel process—the only article he has ever written for an engineering journal; and in one of his characteristic letters he confessed that this was the first time that he had ever made a penny with his pen.

What Dr. Héroult has done has been cheerfully recognized, irrespective of national sentiment. When the Technische Hochschule of Aachen, Germany, opened in 1902 Prof. W. Borchers' new Institute for Metallurgy, Héroult received the honorary degree of doctor ingenieur. Last year France showed that republics are not always ungrateful to their own children, when Dr. Héroult was awarded the grand Lavoisier medal, which is granted every seven years to that French inventor whose work has exercised the greatest influence on the progress of French industries in the field of chemical arts.

In the metallurgy of aluminium, Dr. Héroult has made history. We have every reason to hope that he will be equally

successful in the electrometallurgy of steel, and we may expect the earliest large developments in this country. While, for obvious reasons, it is impossible to state much that is going on in plants owned by corporations, we may say that the Canadian government has appropriated the necessary funds for a large scale test at Sault Ste Marie, while the Lake Superior Power Co. is to provide a building and free power for a limited period. These tests will be under the supervision of Dr. Eugene Haanel, Superintendent of Mines, Ottawa, Ont. Since these tests have to do not only with steel refining, but with the reduction of iron from ores in the electric furnace, their outcome is of very great interest, especially as Dr. Héroult will introduce several entirely novel schemes of his own, in order to utilize the electrical energy to the utmost possible limit.

However, industrial developments of apparently greater importance are soon to be expected in this country with respect to steel refining. In this field Dr. Héroult has with him the best wishes of all American electrochemists and electrometallurgists, besides the practical help of the Halcomb Steel Co., of Syracuse, N. Y., who have put up a plant for the production of 80 tons per day. This plant is to be started in about six weeks. Outside of the two old electric steel plants at La Praz and in Sweden, another large one, using the Héroult furnace, is being completed at Remscheid, in Germany, by the Electrostahl Co., formerly Richard Lindenberg Soehne, while the same process has now also been adopted by the Sault du Tarn Co., in France.

Metallurgical Calculations.—VII.

By J. W. Richards, Ph. D.

Professor of Metallurgy in Lehigh University.

THERMOPHYSICS OF CHEMICAL COMPOUNDS.

The metallic oxides are the most important compounds occurring in metallurgy, together with the oxides of hydrogen, carbon and of sulphur, arsenic and antimony, which are formed during combustion and in roasting operations. We do not include as oxides those combinations of two or more oxides in chemical proportions, such as of silica with metallic oxides, which form oxygen salts or ternary oxygen compounds. They will be separately discussed. In the following lists Sm, as before, means the mean specific heat per kilogram, in large Calories (or per pound in lb. Cal.) in the range of temperature given; S means actual specific heat at the temperature given, and Q is the quantity of heat absorbed in fusion or volatilization or in passing through any designated range of temperature. Temperatures are given only in centigrade degrees, excepting that *t* signifies Fahrenheit temperature; volumes of gases are understood as being at 0° C. and 760 m. m. pressure, unless distinctly stated otherwise.

Oxides.

Hydrogen Oxide, H^2O:

Ice	Sm (−78° — 0°)	= 0.463 (Regnault)
	(−30° — 0°)	= 0.505 (Person)
Water	Sm (0° — 100°)	= 1 + 0.00015t (Pfaundler)
	S (at 15°)	= 1.0045 (Pfaundler)
	S (at 0°)	= 1.0000 (assumed)

In all metallurgical calculations it will be sufficiently exact to assume the specific heat of water at ordinary temperatures as unity. In heating to the boiling point, from zero, 101.5 Calories.

Gas:

Sm (0° to t°)

1 m^3 up to 2000°	= 0.34 + 0.00015t (Mallard and Le Chatelier)
1 m^3 2000° — 4000°	= 0.48 + 0.00017t (Vielle)
1 ft^3 up to 2000°	= 0.021 + 0.000009t — lb. Cal.
1 ft^3 2000° — 4000°	= 0.030 + 0.000011t — lb. Cal.
1 kilo. up to 2000°	= 0.42 + 0.00185t — Cal.
1 kilo. 2000° — 4000°	= 0.59 + 0.00021t Cal.
1 lb. up to 2000°	= 0.42 + 0.00185t — lb. Cal.
1 lb. 2000° — 4000°	= 0.59 + 0.00021t — lb. Cal.
1 ft^3 up to 3600° *F*	= 0.038 + 0.000009*t* B. T. U.
1 ft^3 3600° — 7200° *F*	= 0.054 + 0.000011*t* B. T. U.
1 lb. up to 3600° *F*	= 0.76 + 0.00185*t* B. T. U.
1 lb. 3600° — 7200° *F*	= 1.06 + 0.00021*t* B. T. U.

Above figures are for water vapor as it exists in almost all metallurgical problems, as true gas far removed from its maximum tension at any given temperature. When the water vapor exists as saturated steam under its maximum tension, as in a steam boiler, it is recommended to consult tables giving the total heat in steam at any temperature condensing to liquid water at 0°, or to use Regnault's formula for the same:

$$Q = 606.5 + 0.305t$$

which expresses the amount of heat required to convert 1 kilogram of water, liquid at 0°, into steam at its maximum pressure at the temperature *t*. A little reflection will show that the above formula amounts to taking the specific heat of a kilogram of saturated steam, under a constantly *increasing pressure*, as $Q = 0.305t$

or under increasing pressure $Sm = 0.305$

or per cubic meter (0.81 kilos.) $Sm = 0.247$

These figures apply to boiler practice only. In cases where water is evaporated at or below 100° C., and converted afterwards into steam at a high temperature, I recommend first calculating the heat required to convert the water into vapor at 0° (606.5 Cal.), and then treating the vapor afterwards as true gas, by the formulæ of Mallard and Le Chatelier. This puts water vapor at once, from the beginning, on the same footing as all the other gases, and greatly simplifies all subsequent calculations, without introducing any unnecessary errors.

Latent heat of fusion	= 80 Cal. (Bunsen)
Latent heat of vaporization	= 606.5 Cal. at 0° (Regnault)
	= 600.0 Cal. at 10°
	= 537.0 Cal. at 100° (to vapor at 760 m. m.)
Total heat in saturated steam	= 606.5 + 0.305t (Regnault)

Most metallurgical problems which have to do with converting moisture in fuel, ores, etc., into vapor, are concerned with the evaporation of the water far below 100° by means of dry gases, into which the water vapor enters at a partial pressure, which is only a small fraction of atmospheric pressure. The problem is, in these cases, to find how much heat is necessary to convert the water into vapor at the low temperature corresponding to such low pressure. By finding the temperature corresponding to said partial pressure, as a maximum tension, applying Regnault's formula, we get the heat absorbed in producing the vapor at that temperature. We can then add to this the heat required to raise the vapor up to the higher temperature at constant pressure, using Mallard and Le Chatelier's formulæ.

Example: Wet peat in a kiln is dried by hot air, the issuing air being at 50° C. and the tension of the moisture in it 25 millimeters. How much heat is absorbed in latent heat, and how much as sensible heat per 1 kilogram of water evaporated?

Solution: The tension, 25 millimeters, is the maximum tension of aqueous vapor at 26° (Tables). To change 1 kilogram of water at zero to saturated vapor at 26° requires, according to Regnault's formula, 606.5 + 0.305 (26) = 614 Calories. (The real latent heat of vaporization at 26° is, therefore, 614 — 26 = 588 Calories.) The heat required to evaporate 1 kilogram of water under the conditions of the peat kiln is therefore:

Heat to raise to vapor at 25 m. m. (26°) = 614.0 Calories
Heat to raise vapor from 26° to 50° (constant pressure) = [0.42 + 0.000185 (50 + 26)] × (50 − 26) = 10.4 "
Total = 624.4 "

In most cases of drying or evaporation the results will be sufficiently accurate by assuming the water first evaporated at 0°, with latent heat of evaporation 606.5 Calories, and then raised as gas to the end temperature. The difference between this method and the above will be small, where the temperature of the issuing gas is below 100° and the proportion of vapor in it small; where the temperature of issuing gas is high and the amount of vapor in it large, the more exact method should be used. To facilitate this, the maximum tension of aqueous vapor for temperatures up to 100° is here given:

Temperature C°	*Max. Tension, m. m. of Merc.*	*Temperature C°*	*Max. Tension, m. m. of Merc.*
0°	4.6	50°	92.0
5°	6.5	55°	117.5
10°	9.1	60°	148.9
15°	12.7	65°	187.1
20°	17.4	70°	233.3
25°	23.5	75°	288.8
30°	31.5	80°	354.9
35°	41.8	85°	433.2
40°	54.9	90°	525.5
45°	71.4	95°	633.7
50°	92.0	100°	760.0

Beryllium Oxide, Be^2O^2:
Sm (0° — 100°) = 0.2471 (Nilson and Pettersson)

Boric Oxide, B^2O^3:
Sm (16° — 98°) = 0.2374 (Regnault)

Carbonous Oxide, CO:

Sm (0° to t°) 1 m³ up to 2000°	= 0.303 + 0.000027t (Mallard and Le Chatelier)
1 m³ 2000° — 4000°	= 0.2575 + 0.000072t (Berthelot)
1 ft³ up to 2000°	= 0.0189 + 0.0000017t lb. Cal.
1 ft³ 2000° — 4000°	= 0.0161 + 0.0000045t lb. Cal.
1 kilo. up to 2000°	= 0.2405 + 0.0000214t Cal.
1 kilo 2000° — 4000°	= 0.2044 + 0.000057t Cal.
1 lb. up to 2000°	= 0.2405 + 0.0000214t lb. Cal.
1 lb. 2000° — 4000°	= 0.2044 + 0.000057t lb. Cal.
1 ft³ up to 3600° *F*	= 0.0341 + 0.0000017*t* B. T. U.
1 ft³ 3600° — 7200° *F*	= 0.0290 + 0.0000045*t* B. T. U.
1 lb. up to 3600° *F*	= 0.4329 + 0.0000214*t* B. T. U.
1 lb. 3600° — 7200° *F*	= 0.3679 + 0.000057*t* B. T. U.

Carbonic Oxide, CO^2:

There has been much doubt about the specific heat of this gas, and several experimenters have given it particular attention. Direct combustion of CO to CO^2 in air has recently given Mallard and Le Chatelier a directly-observed temperature of 2050°, while the formula, which has been so far considered by us as the most reliable (Sm = 0.37 + 0.00027t), leads to 1947°. After renewed consideration of the whole subject the writer considers the best values those given below, because by accepting these they will agree with the observed temperature of combustion, 2050°. We will hereafter use these values instead of the one just above. Above 2000° the values of Berthelot and Vielle are the only ones to be used.

Sm (0° to t°) 1 m³ up to 2050°	= 0.37 + 0.00022t (calculated by Richards)
1 m³ 2000° — 4000°	= 0.815 + 0.0000675t (Vielle)
1 ft³ up to 2050°	= 0.023 + 0.000014t lb. Cal.
1 ft³ 2000° — 4000°	= 0.051 + 0.0000042t lb. Cal.
1 kilo. up to 2050°	= 0.19 + 0.00011t Cal.
1 kilo. 2000° — 4000°	= 0.42 + 0.000034t Cal.
1 lb. up to 2050°	= 0.19 + 0.00011t lb. Cal.
1 lb. 2000° — 4000°	= 0.41 + 0.000034t lb. Cal.
1 ft³ up to 3700° *F*	= 0.041 + 0.000014*t* B. T. U.
1 ft³ 3600° — 7200° *F*	= 0.092 + 0.0000042*t* B. T. U.
1 lb. up to 3700° *F*	= 0.34 + 0.00011*t* B. T. U.
1 lb. 3600° — 7200° *F*	= 0.72 + 0.000034*t* B. T. U.

In all the above formulæ, Q from t° to 0° is equal to Sm multiplied by t; *e. g.*, Q. (0° to t°) 1 m³ to 2050° = 0.37t + 0.00022t².

Nitric Oxide, NO^2:

Sm (27° — 280°) 1 m³	= 1.35 (Berthelot and Ogier)
1 kilo.	= 0.65 Cal.

Magnesium Oxide, MgO:

Sm (24° — 100°)	= 0.2440 (Regnault)
Sm (0° — t°)	= 0.2420 + 0.000016t (assumed)
$Mg(OH)^2$ Sm (19° — 50°)	= 0.312 (Kopp)

Aluminium Oxide, Al^2O^3 (alumina, corundum):

Sm (0° to t°)	= 0.2081 + 0.0000876t (constant by Regnault, coefficient of t by Richards, on a corundum crystal tested up to 1200°)
Melting point	= about 2200°
Latent heat of fusion	= 2.1 T = 51,933 Cal. for Al^2O^3 $= \frac{51,933}{102} = 509$ Cal. per kilo.
Heat in solid at 2200°	= 881 Cal. by formula
Total heat in liquid to 0°	= 1,390 Cal.
Specific heat, liquid	= 0.593 = specific heat of solid at M. P.

Silicon Oxide, SiO^2 (silica, quartz):

Sm (0° to t°)	= 0.1833 + 0.000077t (constant by Regnault, coefficient of t by Richards, on clear quartz up to 1200°)
Latent heat of fusion (at 1750°)	= 135 Cal. (Voigt)
Melting point	= 1900° (Boudouard)
Latent heat of fusion	= 2.1 T = 6,563 Cal. for SiO^2 $= \frac{6,563}{60} = 109.4$ Cal. per kilo. = 135 Cal. (Voigt)
Heat in solid at 1900°	= 626 Cal. by formula
Total heat in liquid to 0°	= 761 Cal.
Specific heat, liquid	= 0.476 = specific heat of solid at M. P.

Sulphurous Oxide, SO^2:

Sm (16° — 202°) 1 m³	= 0.4447 (Regnault)
1 kilo.	= 0.1544

If we assume that the molecular specific heat of SO^2 is 8 Calories (from the rule that the molecular specific heat of a gas at constant pressure is 5 + n, where n is the number of atoms in the molecule) we would have

S (at 0°) 1 m³ $= \frac{8.}{22.22} = 0.36$ Cal.

Combining this with Regnault's value of Sm, we would get the formula

Sm (0° to t°) 1 m³	= 0.36 + 0.0003t
1 kilo.	= 0.125 + 0.0001t

These values are probably accurate enough for furnace calculations, and are very useful in pyritic smelting and the roasting of sulphide ores. While it is always desirable to have direct determinations of such important quantities, yet when they have never been made it is allowable to work out and use the most probable values.

Sulphuric Oxide, SO^3:

The specific heat of this important gas has not been measured. As an approximation we may assume

S (at 0°) per molecule = 9.0 Cal. (assumed)
per m^3 = 0.405 Cal.
per kilogram = 0.10 Cal.

For getting an approximation to Sm we may assume the coefficient of t the same as in NH^3, which contains the same number of atoms and is of analogous formula, and we then have

Sm (0° to t°) per molecule = 9.0 + 0.0036t
per m^3 = 0.405 + 0.00017t
per kilogram = 0.100 + 0.00004t

Calcium Oxide, CaO (lime):

This important datum has not been determined, but since it is so closely analogous to MgO, an approximation may be obtained by assuming that the molecular specific heats of the two compounds are alike. That for MgO is 0.2440 × 40 = 9.76 Calories. That for CaO would therefore be

$$\text{Sm } (24^\circ - 100^\circ) = \frac{9.76}{56} = 0.1743$$

and assuming a usual coefficient of t; for compounds of this type:

Sm (0° — t°) = 0.1715 + 0.00007t

Titanic Oxide, TiO^2:
S (up to 200°) = 0.1790 (Nilson and Pettersson)
Q (0° to 200°) = 35.8 Cal.
Q (0° to t°) for t over 200° = 35.8 + 0.1790 (t — 200) + .000055 $(t - 200)^2$

Chromium Oxide, Cr^2O^3:
Sm (10° — 99°) = 0.1796 (Regnault)

Manganese Oxides:
MnO Sm (13° — 98°) = 0.1570 (Regnault)
Mn^2O^3 Sm (15° — 99°) = 0.1620 (Oeberg)
(Manganite) $Mn^2O^3H^2O$ Sm (21° — 52°) = 0.1760 (Kopp)
(Pyrolusite) MnO^2 Sm (17° — 48°) = 0.1590 (Kopp)

Iron Oxides, Fe^2O^3:
Sm (0° — t°) = 0.1456 + 0.000188t (Regnault and Richards)
Fe^3O^4 Sm (0° — t°) = 0.1447 + 0.000188t (Regnault and Richards)

Nickel Oxide, NiO:
Sm (13° — 98°) = 0.1588 (Regnault)

Copper Oxides:
Cu^2O Sm (19° — 51°) = 0.1110 (Oeberg)
CuO Sm (12° — 98°) = 0.1420 (Regnault)

Zinc Oxide, ZnO:
Sm (0° — t°) (to t = 1000°) = 0.1212 + 0.0000315t (Richards)

Arsenious Oxide, As^2O^3:
Sm (13° — 97°) = 0.1276 (Regnault)

Zirconium Oxide, ZrO^2:
Sm (0° — 100°) = 0.1076 (Nilson and Pettersson)

Columbic Oxide, Cb^2O^5:
Sm (0° — t°) = 0.1037 + 0.000070t (Krüss and Nilson)

Molybdic Oxide, MoO^3:
Sm (21° — 52°) = 0.1540 (Kopp)

Tin Oxide, SnO^2:
Sm (16° — 98°) = 0.0936 (Regnault)

Antimonious Oxide, Sb^2O^3:
Sm (18° — 100°) = 0.0927 (Neumann)

Tungstic Oxide, WO^3:
Sm (8° — 98°) = 0.0798 (Regnault)

Mercuric Oxide, HgO:
Sm (5° — 98°) = 0.0518 (Regnault)

Lead Oxide, PbO:
Sm (22° — 98°) = 0.0512 (Regnault)

Bismuth Oxide, Bi^2O^3:
Sm (20° — 98°) = 0.0605 (Regnault)

Thoric Oxide, Th^2O^3:
Sm (0° — 100°) = 0.0548 (Nilson and Pettersson)

For those metallic oxides whose specific heat have not been determined, an approximation to the specific heat can be found by assuming that the metallic atoms in a molecule of oxide have each a specific heat of 6.4 Calories, and each atom of oxygen in an oxide molecule has an atomic specific heat of 3.6. As a rough approximation, we can further assume that the mean specific heat from 0° to t° increases 0.004 per cent for each degree of temperature, so that the above calculated specific heat being from 0° to 100°, we can figure out S at zero and the rate of increase of S or Sm with t.

Example: What is the most probable value of the specific heat of CaO? Since molecule weight is 56, and the molecule may be assumed to have a molecular specific heat of 6.4 + 3.6 = 10.0 Calories, the mean specific heat per kilogram (0° — 100°) is 10.0 ÷ 56 = 0.1786. S at zero will then be 0.1786 ÷ 1.004 = 0.1779, and we would have the formulæ:

Sm = 0.1779 + 0.000071t
S = 0.1779 + 0.000142t
Q = 0.1779t + 0.000071t^2

Problem 11.

The Jacobs process of producing artificial emery consists in melting down impure bauxite in an electric furnace, and letting the mass cool. Assume the bauxite to be calcined before use, and to contain

	Per Cent.
Alumina (Al^2O^3)	88
Ferric oxide (Fe^2O^3)	5
Silica (SiO^2)	5
Titanic oxide (TiO^2)	2

Required:

(1) The heat necessary to just melt a metric ton of this material at 2000°.

(2) The net electric power theoretically required.

(3) The total electric power actually required.

Solution:

(1) Because of the presence of the impurities the alumina melts easier than it otherwise would. We can, therefore, calculate the heat in the alumina melted at 2000°, and the heat in the others melted at their proper melting points, because they absorb their latent heats of fusion at the lower temperatures. Take 1000 kilos. of material.

Heat in 1 kilo. of alumina:
Q (0° — 2000°) = 0.2081 (2000) + 0.0000876 $(2000)^2$ = 767 Cal.
L. H. F. at 2000° = 2.1 (2000 + 273) ÷ 102 (mol. wt. Al^2O^3) = 47 "
Total = 814 "

Heat in 1 kilo of ferric oxide:
Q (0° — 1600°) = 0.1447 (1600) + 0.000188 $(1660)^2$ = 713 "
(assumed)
L. H. F. at 1600° = 2.1 (1600 + 273) ÷ 160 = 25 "
Heat in liquid = (2000 — 1600) × 0.59 = 236 "
Total = 974 "

Heat in 1 kilo. of silica:
Q (0° — 1900°) = 0.1833 (1900) + 0.000077 $(1900)^2$ = 626 "
L. H. F. (Voigt) = 135 "
Q (1900° — 2000°) liquid = 0.476 × 100 = 48 "
Total = 809 "

Heat in 1 kilo. of titanic oxide:

$Q\ (0^\circ - 2000^\circ) = 35.8 \times 0.1790\ (1800) + 0.000055\ (1800)^2 = 536$ "

L. H. F. $= 2.1\ T = 2.1\ (2000 + 273) \div 80 = 59$ "

Total = 595 "

Total heat to fuse 1000 kilos.:

Heat in alumina	$880 \times 814 =$	716,320 Cal.
Heat in ferric oxide	$50 \times 974 =$	48,700 "
Heat in silica	$50 \times 809 =$	40,450 "
Heat in titanic oxide	$20 \times 595 =$	11,900 "
	Total =	817,370 "

(2) One kilowatt equals 859 Calories per hour.

Kilowatt-hours absorbed by melt $= \frac{817{,}370}{859} = 951.5$ kw-hours.

(3) Assume an efficiency of 50 per cent, requires 1903 kw-hours. If the dynamos work at 95 per cent efficiency, the working power of the water turbines, gas engines or steam engines would be $\frac{1903}{0.95} = 2000$ kw-hours.

Problem 12.

The ferric oxide charged into a blast furnace is reduced at 900° C. by carbonous oxide gas, CO, according to the reaction:

$$Fe^2O^3 + 9CO + (13.15N^2) = Fe^2 + 3CO^2 + 6CO + (13.15N^2)$$

Required:

(1) The thermal value of the reaction at 900°.

(2) What would be the temperature of the resulting products after the reaction had occurred?

Solution:

(1) The 6CO and $13.15N^2$ occurring on both sides of the equation need not be considered. The heat value of the equation at *ordinary temperatures* would therefore be:

Decomposition of Fe^2O^3	$= -$	195,600 Cal.
Decomposition of 3CO	$= -$	87,480 "
Formation of $3CO^2$	$= +$	291,600 "
Thermal value of reaction	$= +$	8,520 "

At 900°, the value is changed as follows:

Added:

Heat in Fe^2O^3 (160 kilos) at 900° = $160\ [0.1447\ (900) + 0.000188\ (900)^2]$	$= +$	45,200 "
Heat in 3CO (= $66.66m^3$) at 900° = $66.66\ [0.303\ (900) + 0.000027\ (900)^2]$	$= +$	19,640 "
Total to be added	$= +$	64,840 "

Subtracted:

Heat in Fe^2 (112 kilos.) at 900° = $112\ (0.218t - 39)$	$=$	17,585 "
Heat in $3CO^2$ ($66.66m^3$) at 900° = $66.66\ [0.37\ (900) + 0.00022\ (900)^2]$	$=$	34,080 "
Total to be subtracted	$=$	51,665 "

Heat of reaction at 900° = 8,520 + 64,840 − 51,665 = + 21,695 "

(2) The above heat would serve to raise the temperature of all the products, viz.: Fe^2, $3CO^2$, 6CO and $13.15N^2$ (from blast).

Their thermal capacity, 900° to t, is:

$Fe^2 = 112\ [0.218\ (t - 900)]$

$3CO^2 = 66.66\ [0.37\ (t - 900) + 0.00022\ (t^2 - 900^2)]$

$6CO = 133.33\ [0.303\ (t - 900) + 0.000027\ (t^2 - 900^2)]$

$13.15N^2 = 13.15\ [$ " " $]$

Sum $= 0.018625t^2 + 93.47t - 99.205 = 21.695$ Calories

Whence $t = 1046^\circ$

It follows from the preceding discussion that the reduction of iron oxide by CO, at about 900°, is an exothermic reaction, heat being evolved, and that the reaction proceeds to a finish when once started. The relations for FeO would be probably similar, but we do not have the specific heat of FeO to use in making the exact calculation.

Problem 13.

If Fe^2O^3 charged into a blast furnace were reduced by solid carbon, at 900° C., by the reaction:

$$4Fe^2O^3 + 9C = 3CO^2 + 6CO + 4Fe^2$$

Required:

(1) The thermal value of the reaction at 900° C.

(2) The temperature of the resultant products after the reaction.

Solution:

(1) Value of the reaction at zero	$= -$	4 (195,600) Cal.
		+ 3 (97,200) "
		+ 6 (29,160) "
	$= -$	315,840 "
Add:		
Heat in $4Fe^2O^3$ at 900°	$= +$	180,800 "
Heat in 9C at 900° $= 9(12)\ [0.2142\ (900) + 0.000166\ (900)^2]$	$= +$	35,340 "
Subtract:		
Heat in $4Fe^2$ at 900°	$= -$	70,340 "
Heat in $3CO^2$ at 900°	$= -$	34,080 "
Heat in 6CO at 900° $= 6(22.22)\ [0.303\ (900) + 0.000027\ (900)^2]$	$= -$	39,275 "
Algebraic sum	$= -$	243,395 "
Absorbed per molecule of Fe^2O^3	$= -$	60,850 "

This reaction is therefore strongly endothermic, and therefore tends to check itself constantly by the resultant cooling effect.

(2) If the Fe^2O^3 and C were at 900° to start with, the products would be below 900° after the reaction, since they would have to furnish the deficit of heat.

The products would give out in cooling from 900° to t°.

$4Fe^2 = 4(112)\ [0.218\ (900 - t)]$

$3CO^2 = 66.66\ [0.37\ (900 - t) + 0.00022\ (900^2 - t^2)]$

$6CO = 133.33\ [0.303\ (900 - t) + 0.000027\ (900^2 - t^2)]$

Sum $= -0.0183t^2 - 162.73t + 161{,}250 = 243{,}395$ Cal.

Whence $t = -537^\circ$

This result is, of course, due to the hypothetical assumption that this endothermic reaction would go on until completed without checking itself. The impossible result obtained means that if this single reaction really goes on, it will soon check itself on account of the decrease of temperature.

Colby Kjellin Furnace.

The legend under Fig. 3, on page 299 of our August issue, contains an unfortunate error. It should read "Diagram of Colby Furnace" instead of "Diagram of Kjellin Furnace." This error will probably have been evident to our readers from the accompanying remark that the diagram was reproduced from patent 428,552, granted on May 20, 1890—this is one of Mr. Edward A. Colby's patents. The diagram is most interesting since it shows how much of the latest designs of the induction furnace was anticipated by Mr. Colby as early as 1890.

As already mentioned on page 134 of our April issue there were granted three fundamental patents to Mr. Colby in 1890. They are Nos. 428,378, 428,379 and 428,552, May 20, 1890. The first footnote on page 299 of our last issue should be corrected accordingly.

The Electrochemistry of the Metallic Arc.

By Isador Ladoff.

(*Continued from page 303.*)

Child determined the following data of comparative resistance of the metallic electrodes:

Metal.	Resistance of Anode. Volts.	Resistance of Cathode. Volts.
Zinc	12	14
Iron	13	15
Copper	11	14

V. v. Lang (Wied. Ann. 31, p. 384, 1887) determined the tension of different metallic electrodes and expressed them by means of Froelich's formula. The constant "a" in this formula, called by V. v. Lang the "counter electromotive force" of the arc, represents the tensions below which no arc can be maintained.

The results secured by V. v. Lang we put here side by side with the data secured by Monasch (Wied. Ann. 58, p. 73, 1896). The first data for "a" relate to arcs in the usual atmosphere, the second in an atmosphere of nitrogen:

Metals.	Constant "a" in Air. Volts.	Constant "a" in Nitrogen. Volts.
Platinum	27.41 ± 1.16	29 — 31
Aluminium		26 — 29
Nickel	26.18 ± 2.95	
Magnesium		21 — 23
Iron	25.03 ± 2.16	19 — 22
Copper	23.86 ± 1.33	29 — 32
Zinc	19.86 ± 2.27	21 — 22
Silver	15.23 ± 0.45	
Cadmium	10.28 ± 3.38	21 — 22
Lead		18

It appears obvious that each metal has its own constant "a," the value of which is smaller for nitrogen than for air. V. v. Lang noticed that the constant "a" is higher for metals with a higher melting point. For carbon, having the highest melting point, the constant "a" is the highest, namely, 40 volts. Silver, which ought to possess a higher value of "a," taking in consideration its melting point, represents the only exception. In 1897, V. v. Lang (Wied. Ann. 62, p. 569, 1897) found another exception in the constant "a" of aluminium, namely, "a" = 39 volts.

Feussner claims that there is a fixed relation between the constant "a" and the boiling point of metals.

Guye and Monasch (Arch. des Sciences Physiques et Naturelles [Geneve] [14] 15, 15, III, 1903) found that when the length of the arc and the current of a metallic arc are kept constant the electric tension is higher in proportion as the atomic weight of the respective metal is higher. The following table represents the data procured when a current of 0.04 amps. (alternating of 47 periods per second) and an arc of 5 mm. length was maintained:

	Metals.				
	C	Mg	Fe	Ni	Cu
Atomic weight	12	24	55.9	58.6	63.2
Tension	640	700	850	850	870
	Ag	Cd	Pt	Au	
Atomic weight	107.7	115.5	194.3	196.7	
Tension	900	725	1000	1040	

Cadmium appears to be the only exception to the rule.

Schulze (Dissertation, Hannover 27, XI., 02, pp. 25-31) demonstrated that the groups of the periodic system possessing higher atomic weight and higher melting points are distinguished by a comparatively higher drop of potential in the arc, and especially a larger resistance of the anode. Schulze claims that within the same group the loss of tension in the arc is decreasing with the increase in atomic weight (in earthy alkalies). Otherwise there is a certain similarity between the drop of tension in the gaseous arc and the conductance of electricity in the solid body.

Arons (Drud. Ann. 1, p. 700, 1900) investigated the decrease of tension with decrease of pressure below one atmosphere in nitrogen gas in various metallic arcs. For cadmium, for instance, he found the following data: When the current was kept at 1.6 amps. and the length of the arc 1.5 mm. the voltage varied with the pressure as follows: for cadmium,

Pressure in Hg. mm.	10	60	100	220	380	600	750
Volts	12	16	17	21	22	23	23

Magnesium electrodes were tried. The arc was kept at 1.4 mm. length and the current at 4.5 amps., with the following results:

Pressure in Hg. mm.	90	220	360	490	660
Volts	17	17	20	20	22

The tension of the electrodes fell in proportion as the pressure dropped to 20 mm. of mercury.

Guye and Monasch investigated the behavior of the tension of copper electrodes during a diminution of pressure below 1 atmosphere. They used an alternating-constant current of 0.058 amps. of high tension at various constant lengths of the arc, and found that the tension drops together with the pressure. However, the critical point could not be reached. The arc changed entirely its aspect when the pressure fell very low, and turned into a series of spark discharges, as it is observed in rarified gases (Geissler tubes). The arc finally disappeared entirely, and the electrodes were surrounded with violet light, which covered a larger portion of the electrodes the lower the pressure dropped. The space between the electrodes, occupied at the usual pressure by the arc, was filled with a crimson and violet-colored glow, interrupted by a dark zone in the middle. When the current is kept constant and the pressure fluctuates periodically it causes a periodical fluctuation in the tension. When the tension is kept constant the current fluctuates periodically with the pressure.

Very interesting are the changes produced by the temperature in the tension of metallic electrodes.

Becquerel (Ann. Chim. Phys. [31], p. 355, 1853) already proved that electric discharges pass through longer distances and at lower tension in a warmer than in a colder electrode. De La Rive (Archives de l'Electricité 1, p. 262, 1841) heated various electrodes by the means of an alcohol lamp and found that the duration of the arc increased with the temperature of the electrodes.

Tommasi (Comptes Rendus Hebd. de Seances de l'Accad. de Sciences Paris 93, p. 716, 1881) passed an arc between horizontally arranged U-formed copper tubes. He watched the difference between the behavior of the arc when the tubes were artificially cooled by a current of water and then when they were at normal temperature. The luminosity of the arc dropped with the drop of temperature. At the lowest temperature attained the arc approached in its nature spark discharges, and could be easily extinguished. At all times, however, the sparks were colored green, indicating the vaporization of the copper.

Lecher (Sitz. d. K. Acc. d. Wiss. Wien 95, II., p. 992, 1887) experimented with platinum electrodes of 5 mm. diameter arranged horizontally. At a distance of about 2 mm. the electrodes showed about 35 volts tension. After he surrounded the electrodes with a spiral of copper wire, in order to lower their temperature, and repeated the experiment he found the tension lowered to 26 volts. In copper pencils of 4.4 mm. diameter the temperature proved to be so low that only the influence of heating was investigated. The tension of the pencils at 2 mm. distance was about 26 volts. After the heating of one electrode the tension rose to 28 volts, and this rise was greater when the negative was heated than the positive. Silver electrodes of 4.9 mm. diameter at a distance of 2 mm. showed a tension of about 20 volts. The ten-

sion increased to 28 volts when the negative pencil was heated, and to 23 volts when the positive pencil was heated.

The investigation of Arons (Wied. Ann. 58, p. 81, 1896) shows different results from those just presented, namely, a loss of tension when the temperature surrounding the pencils drops. R. Herzfeld doubts (Wied. Ann. 62, p. 442, 1897) if the cooling effect of the copper wire used by Lecher in his experiments was sufficient to produce results. Herzfeld threw a stream of fluid carbonic acid, kept under 38 atmospheres pressure, on the tips of metallic electrodes in order to notice the effect of cooling on the tension. The current was lowered while the tension increased. Herzfeld admits, however, that this result may be due to some chemical causes. The resistance of metallic electrodes increases with the temperature, while the opposite of it is true of carbon electrodes.

Guenther Schulze (Dissertation Hannover 27, XI., 02, p. 33) found that the resistances of both electrodes, cathode and anode, increases when they are cooled down, and that the resistances drop when the artificial abstraction of heat from the electrodes is diminished. G. Schulze could measure the dependence of the resistances of the electrodes from temperature only in the best conductors of heat, copper and silver.

When an arc of 10 mm. length is formed between copper pencils by means of a high-tension alternating current of 0.04 amps., the arc is apparently very quiet and surrounds the tips of both electrodes uniformly. However, when an alternating current of the same amperage is forced across the same electrodes, at a distance of 12 mm., the arc is very unsteady. (Guye and Monasch, Ecl. El. 34, p. 305, 1903.) The one end of the arc raises above the edge of the pencil and then leaps around, climbing on the cylindrical part of the electrode. Frequently the flame of the arc divides itself into several branches. The location of the arc changes every moment when it is about 11 mm. long. There seems to be no regularity in the wandering of the arc from place to place under such conditions. The zone in which the arc is unsteady the investigators call the "unquiet zone" (unruhige zone). In this zone the distance between the pencils is not equal to the length of the arc, but the arc is longer than this distance. As each variation of the length of the arc at constant amperage results in a variation of the tension, the needle of the voltmeter inserted in the circuit while the arc is in the unquiet zone is moving to and fro around a certain value of tension, and it is impossible to take a reading of the voltage. The zone in which the arc is quiet in a high-tension alternating current, and behaves similar to an alternating-current arc between carbons at low tension in respect to the mutual relation of their variable values, is called by the investigators the "normal zone." Any "normal" arc turns unsteady when the distance between the pencils is increased beyond a certain length. The distance between electrodes, causing unquietness of the arc, generally depends on the nature of the electrode. In the experiments conducted by Guye and Monasch the length of the arc at a constant current of 0.04 amps., above which the arc turned unsteady, proved to be as follows:

	mm.
Magnesium	15.0
Cadmium	13.0
Silver	11.0
Copper	10.5
Nickel	9.5
Iron (chemically pure)	8.0
Platinum	6.0
Aluminium	5.0
Gold	4.5

In the "normal" zone it is possible to take careful readings of the electric values. The regularity prevailing in the carbon arc is characteristic of a metallic arc at high tension. The effective tension of metallic electrodes producing an arc in a high-tension alternating current increases with the distance between the pencils occupied by the arc if the efficient current remains constant. When the length of the arc is kept constant a lower tension corresponds to a higher current. Guye and Monasch investigated the high-tension alternating-current arc of the following metals: Silver, copper, platinum, gold, nickel, iron, aluminium, magnesium and cadmium. In all metals the relation between the length of the arc and tension of the pencils could be expressed graphically in a straight line if the current is kept constant. Only the aluminium arc was unsteady under the same conditions under which other metallic arcs remained normal, on account of the formation of a thick crust of earthy, insulating oxides, over and above which the arc climbs to the unoxidized parts of the pencils. The application of Froehlich's formula to high-tension alternating current arcs has little value, as the constants "a" and "b" vary with each current.

(To be Concluded.)

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

THE FARADAY SOCIETY.

Of the papers discussed at the July meeting of the Faraday Society, first place was given to that by Mr. Sherard Cowper-Coles, on the rapid deposition of copper. The first speaker was Mr. W. R. Milburne, who stated that a plant put up on the Continent had fulfilled all Mr. Cowper-Coles' claims, demonstrating the value of the centrifugal process on a practical scale. Indeed, the larger the sheets required, the better had been the results. There had, of course, been a few minor initial difficulties, such as driving the mandril and securing the circulation of the electrolyte, but these had all been overcome. Mr. Prebble referred to the value of the centrifugal process in repelling the air bubbles, and stated that circulation began at the right place, the electrolyte acting as a liquid burnisher. Dr. Steinhart referred to the importance of the industry, particularly in the United States, where 250,000 to 300,000 tons of copper were refined electrolytically in each year. He regarded the process as eminently suited to the duties described in the paper. He wants, however, to know whether impurities were present in the anode, and, if so, with what percentage of impurities was it possible to work. He congratulated the author on having prepared a paper which, as a whole, was the most interesting that the society had had for a long time. Mr. Cloud spoke as one having no practical experience of rapidly rotating cathodes. He disagreed with the author's view that the formation of nodules on plates was due to a small particle of impurity. He (the speaker) had found that the use of glue gave smooth plates, but was unable to explain the reason. The smoothness obtained by Mr. Cowper-Coles' method was not due so much to a burnishing action of the electrolyte, but to a dragging out of the crystal. Two communications were then read, the one from Mr. McKenzie asking for particulars of the voltage and current density employed, and the other from Mr. A. S. Elmore, which virtually amounted to an abstract of a paper on the Elmore process. He claimed that the Elmore process had yielded more than Mr. Cowper-Coles claimed for his centrifugal process, and asked whether Mr. Cowper-Coles could make tubes of less than 2½ inches diameter. In reply Mr. Cowper-Coles referred those who had asked for details of voltage and current density to a diagram which gave these. In reply to Dr. Steinhart's query, Mr. Cowper-Coles stated that he had used Chili bars for his anodes, and the lowest grades with which they had worked contained 93 per cent of copper. As regards nodules, he believed that the seat of each of these was a speck of dirt in mechanical suspension, but not in solution. Sir Joseph Swan held this view. As to Mr. Elmore's communication, it was easiest in all electrolytic processes to obtain relatively large tubes and draw these down.

Prof. Haldane Gee's paper on "The Use of Balanced Elec-

trodes," was introduced by Mr. Hutton, who spoke of the trouble involved in weighing the electrodes in a voltameter, and the manifest value of a continuous balance for the purpose. The discussion on the paper was practically confined to a few observations by Dr. F. Mollwo Perkin, who remarked that the subject was one of considerable interest to him, as he had endeavored to produce a coulomb-meter which should act as a substitute for the voltameter. He had found that large anode surfaces were necessary when using a mercury coulomb-meter, which should be worked across the terminals of a shunt resistance placed in the main circuit. The best coulomb-meter was undoubtedly a gravity balance with the cathode hung on one arm.

Dr. Perkin then gave abstracts of the two papers by himself and Dr. Law, the one on the "Electrolytic Analysis of Antimony," and the other on the "Electrolytic Oxidation of Hydrocarbons of the Benzene Series. Part II., Ethyl Benzene, Cumene and Cymene." Partly owing to the lateness of the hour, and perhaps in part to an unwillingness to challenge Dr. Perkin on questions in organic chemistry, the discussion on the second of these papers was confined to the propounding of two questions and their answers. Replying to Dr. Borns' query as to whether, if acetic acid were used in place of acetone, the substances would not go into carbon dioxide and a certain amount of tar, Dr. Perkin said that his experiments had yielded mainly alcohol and very little aldehyde. Acetic acid had not yet been obtained. Replying to Mr. W. R. Cooper no work had yet been done on the chain compounds—they had tried to saponify petroleum, but with no satisfactory result.

Mr. R. S. Hutton's synopsis of the paper on "Heat Insulation, Particularly with Regard to Materials Used in Furnace Construction," of which he was joint author with Mr. J. R. Beard, was received with considerable interest. A written communication criticised the use of the water jacket, and referred to some experiments recently carried out at Finsbury. In these no jacket was used, but the substance was raised to a uniform heat, and the amount of heat required to keep this constant was measured. The writer praised Canadian mica, saying it was as good as any of the media Mr. Hutton had tested. In reply, Mr. Hutton stated that he was aware of the experience referred to, and thought their method good enough for applying to steam pipe coverings. For furnace linings he defended the method described in his paper as better and of more practical utility.

Before actually adjourning for the holidays—the formal adjournment having begun when the vote of thanks to Dr. Hutton and Mr. Beard was passed by acclamation—those present gathered around Mr. Cowper-Coles' specimens of centrifugally deposited copper, which were both numerous and interesting.

The Galbraith-Stewart Electrothermic Process of Producing Steel from Iron Sands.

In company with the representatives of the leading English technical papers, a number of members of the Faraday Society and some iron and steel manufacturers, I went to the Brush Works at Loughborough to view the Galbraith Stewart experimental furnace. This is of the resistance type, and consists of graphite bars. No meters were fitted for measuring the current supplied, but we were informed that this was supplied from a 100-kw. alternator, and was transformed down to about 18 volts. The graphite bars were arranged in parallel, the current entering at the front and leaving at the back. Contact is made with the bars by means of substantial iron blocks, pressed against the graphite grids by means of a weighted lever. The bars become incandescent, and fine granular iron sand is fed continuously from the top of the furnace, dropping into a receptacle at the bottom in a molten condition.

The invention is a New Zealand one, and is the latest attempt to treat the huge beach deposits of almost pure iron sand which have hitherto defied the metallurgist. An analysis by Mr. W. H. S. Shakell, which is quoted as typical of these sands, gives the following percentage analysis: Peroxide of iron, 67.04; protoxide of iron, 30.17; manganese peroxide, 0.22; aluminium oxide, 0.16; silica, 0.50; titanium, 1.60; calcium and titanium, traces, and 0.31 undetermined.

At the outset it was manifest that the furnace was still in the laboratory stage. For instance, the heat radiation was very large, the infeeding of cold sand slow (about 1 pound per minute), and the resultant material merely consisted of nodules of the metal. To dwell too much on these would be ungenerous, as Mr. Stewart, who, in a lucid and honest speech, modestly declared that the experiments were not on a commercial scale; the only change which could be shown was from the granular to the globular form. Ultimately, Mr. Stewart said, a molten bath would be provided whence the molten metal required for ingots could be run off. As exhibited the sand was mixed with a small quantity of carbon and fed cold into the furnace. In the future it was proposed to heat the sand with producer gas, bringing it to a red heat and feeding into the furnace in a reduced state, the conversion into steel being effected during its passage over and between the incandescent electrodes, thence falling into a hot bath for tapping. Strictly speaking, there would be no intermediate pig iron stage, the oxygen required being present in the form of peroxide and protoxide.

To those who, like your correspondent, went in the hope of seeing more than globules of iron or steel, the demonstration was disappointing. Some small ingots were exhibited, but these were the product of globules of the iron smelted in crucibles heated in an ordinary coke foundry furnace. Many obvious questions call for answer, such as the energy actually required, the life of the electrodes, losses in radiation and contact resistance, and analyses of the ultimate product. Several English metallurgists hold the view that induction furnaces of Kjellin type are better fitted than resistance furnaces for dealing with minute particles of iron. The Galbraith Stewart process has yet to vindicate itself; if it can do this it becomes at once evident that its field is not restricted to deposits of iron sand, but that magnetically separated particles of iron ore may be treated directly by it without the need for preliminary briquetting, concerning which one hears so many adverse comments, based on the fragile character of the briquettes.

Papers on Iron and Steel at the Mining and Metallurgical Congress at Liege.

I was unable to leave London for the meeting of this Congress, and, therefore, did not secure immediate copies of the papers read. My own copies, as a subscriber to the Congress, are, unaccountably, not yet to hand, so I am therefore constrained to send abstracts of the reprints of the papers read which have been published in contemporary English journals. Many of the papers which were presented partook of the nature of reviews of the progress along certain lines. Among these may be mentioned Mr. Hadfield's paper on "The Effect of Liquid Air Temperatures on the Properties of Iron and Steel," which was virtually a summary of the paper read last May at the Iron and Steel Institute. The paper by M. O. Ackers is a résumé of recent open-hearth steel processes. It contains, however, some particulars of the practice followed at the Jurgewka Works, Donetz, where the available ores are too high in phosphorus for the Bessemer process, while too low for the basic process. Here the furnaces are first charged with ore and heated in the furnace until the ladles of liquid pig are brought up and their contents poured into the furnace. The decarburization of the pig iron in contact with the mineral oxides takes place, and produces a violent reaction, which hastens the end of the operation; in five hours from the time of charging, 25 to 30 tons of steel may be run out. At the Jurgewka Works there are five 25 to 30-ton furnaces supplied with metal from a 150-ton mixer. The metal shows the following average composition:

Silicon.	Manganese.	Sulphur.	Phosphorus.
1.0 to 1.5	2.25 to 3.0	0.0 to 0.3	0.15 to 0.25

Krivoi-Rog ore, containing 65 per cent of iron and 0.10 per cent of phosphorus, is used.

The results obtained at these works are remarkable. During July, 1904, 13,754 tons of good ingots were made on a working equal to 140 days and 570 charges, or 98 tons per twenty-four hours per furnace. A 20 per cent saving of coal was effected. The average composition of a charge was 25,724 kilos. of liquid iron and 176 kilos of ferromanganese, 6240 kilos. of ore and 2400 kilos of fluxes. The working of the charge occupied five and one-half hours from charging to tapping. The composition of the pig iron used and of the steel obtained were as follows:

	C.	Si.	Mn.	S.	Ph.
Pig iron.....	4.25	1.17	2.80	0.03	0.20
Steel	0.07	0.01	0.50	0.03	0.04

Five thousand kilos. of slag were produced containing:

Si.	Mn.	S.	Ph.	Fe.	CaO.	AlO.	MgO.
24.8	14.40	0.14	0.46	1.10	35.55	1.80	9.7

After describing the Bertrand-Thiel and Talbot processes, together with the Suzycki modification of the latter, the author concludes with the following summarized conclusions:

"Charging open-hearth furnaces with liquid pig iron is so convenient and economical that there is no doubt it should be adopted, and that with this view new open-hearth plants should always be erected in the vicinity of blast furnaces. The advantages arising from this selection of site are:

"1. Economy of labor in handling the output of the blast furnaces and in charging the steel furnace.

"2. The time of working a charge being diminished by using liquid pig iron, production per furnace can be increased.

"3. Manufacture of steel is independent of the quality or cost of scrap, of which the percentage proportion per charge can be adjusted to suit the supply.

"4. The steel works can reap the advantage accruing from the use of the waste blast furnace gases for power purposes.

"5. The fuel economy is considerable.

"When ores containing not too much phosphorus are available, as at Jurgewka, the ordinary process of charging liquid pig iron may be followed; with ores higher in phosphorus, but containing less than 1.8 per cent, the Bertrand-Thiel process may be tried; when a mild steel is required, the Talbot and Surzycki processes give good results. As long, however, as ores—and, consequently, pig iron—high in phosphorus are found abundantly, open-hearth processes in general will have a worthy rival in the basic Bessemer process."

MAGNETIC ALLOYS OF NON-MAGNETIC MATERIALS.

In my July letter I thought I had, for a while at any rate, exhausted my tributes to Mr. Hadfield's versatility. A paper on "The Magnetic Qualities of Some Alloys Not Containing Iron," of which Mr. Hadfield appears as joint author with Prof. Fleming, read on June 8 before the Royal Society, has disillusioned me. In connection with this research it is not the present commercial value of the products which counts, for that is poor, but the potentialities opened up, which are very great indeed. The alloys which formed the subject of the paper contained in the one case, manganese, 22.42 per cent; copper, 60.49 per cent; aluminium, 11.65 per cent. There was a certain amount of intermingled slag, probably 2 or 3 per cent, mostly consisting of MnO and SiO_2, and slight traces of other metals. Aanalysis showed that there was also present: Carbon, 1.5 per cent; silicon, 0.37 per cent, and iron, 0.21 per cent. Hence, it may be said that nothing but a trace of iron occurs in this sample of alloy. The other ring, No. 1,888/7, had an approximate composition: Manganese, 18 per cent; copper, 68 per cent; aluminium, 10 per cent; lead, 4 per cent. These alloys, unfortunately, have poor mechanical properties and are brittle and cannot be forged. Rings were cast from the material and turned in the lathe to the desired form. The rings having been carefully shaped, their dimensions were then measured. The ballistic method of testing was employed for the purpose of obtaining the magnetic data. Omitting the ten tables which appear in the paper, the following conclusions are reached respecting the behavior of the ring, whose analysis is first given: (1) the alloy exhibits magnetic properties which are identical with those of a feebly ferromagnetic material. (2) The magnetization curve is of the same general form as that of a ferromagnetic metal such as cast iron, and indicates that with a sufficient force a state of magnetic saturation would most probably be attained. (3) The alloy exhibits the phenomenon of magnetic hysteresis. It requires work to reverse the magnetization of the material and to carry it through a magnetic cycle. (4) The material has a maximum permeability of 28 to 30, which is not greatly inferior to that of the values reached for cobalt or a low grade of cast iron for small magnetic forces, and occupies a position intermediate between permeability of the ferromagnetic and the merely paramagnetic bodies, such as liquid oxygen and ferric chloride. (5) The material exhibits, therefore, the phenomenon of magnetic retentivity and coercivity. It is not merely magnetic, but can be permanently magnetized. The alloy composing the second ring, when tested, was found to have a flatter magnetization curve than the alloy No. 1871. Its hysteretic properties closely approximated to that of the first tested alloys. Both of these have far greater hysteresis than pure iron-nickel or cobalt for corresponding cycles of magnetization.

This, of course, is only a detailed investigation of Dr. Heusler's discovery in regard to which Mr. Hadfield exhibited a sample at the British Association Meeting at Cornbridge in 1904. But what is of importance is the hypothesis Mr. Hadfield and Prof. Fleming advanced that ferromagnetism is not a property *per se* of the chemical atom, but of certain molecular groupings. "In spite of the fact that ferromagnetism has been hitherto regarded as the peculiar characteristic of certain chemical compounds—iron-nickel and cobalt—it may, in fact, depend essentially on molecular groupings composed of a comparatively large number of molecules, and hence it may be possible to construct alloys which are as magnetic, or even more magnetic, than iron itself." In this sphere, with such a goal, a half decade is not too long a period to give to the thorough investigation of the question.

THE MINIMUM SCIENTIFIC TRAINING.

Some remarks of Prof. Sir Alexander Kennedy's on "The Academic Side of Technical Training," made before the Union Society of University College, London, while neither electrochemical nor electrometallurgical in their context, are of such importance that I feel constrained to quote them here. Sir Alexander Kennedy, who is responsible for the design of the conduit system of electric traction adopted in South London by the London County Council, said: "The idea of giving a young man just as much mathematics, just as much physics, or just as much chemistry as the minimum that he can professionally require, is not only pernicious, but absolutely fallacious. I am sure that the only way of knowing a subject up to a certain point, in such a fashion that, up to that point, it can be thoroughly utilized, is to study the subject up to a point very much further advanced. It is not at all a valid objection to the teaching of any particular point in mathematics or physics, that it is more complicated or more advanced than anything which the engineer will be likely to require. That, in itself, is not an objection at all, because, as I have said, it is impossible really to master a scientific subject up to a certain, often very elementary, point without having at least a superficial knowledge of a much greater extent of the subject. But it is desirable, indeed necessary, from our point of view, that the advanced work in purely scientific subjects should be specially chosen, so as best to deepen and make certain the knowledge of the earlier work." All who

have had to deal in any manner with the technical training of engineers or chemists, or have had to depute duties to the technically trained product of various institutions, will at once recognize the importance of these truisms, and impress them on their subordinates. The reason, perhaps, why so many fail to think intelligently is because their mental horizon is bounded by their daily occupations, which they fail to appreciate in an adequate manner, through being only partially trained, and which they do not extend by independent study.

MARKET QUOTATIONS.

With regard to the alkaline products, prices are stationary, although the fear of labor troubles on the one hand and advanced prices for raw cotton on the other, will probably depress the Lancashire demand and tend to lower prices. In sympathy with the hardening in the price of copper, copper sulphate has risen to £21 per ton. The price of shellac continues its see-saw course, having risen during the month to £9 per cwt.

Cleveland pig iron remained steady at £2.5.6 per ton until July 12, then receding a fraction. The expected recovery began about the 21st, the closing price on July 31 being £2.6.6, and further rises are now expected. Copper rose steadily throughout the month to £68.10.0 per ton, and the indications to-day point to further rises. Tin has furnished the sensation of the month, touching the phenomenal price of £151 per ton on July 26, a rise of over £12 in twenty-three days. A slight fall to £149 took place by the 31st, but prices are hardening again, owing to shrinkage of supplies and the well-maintained demand. Lead has been firm in price, closing at £14.5.0 for ingots. Quicksilver is fetching from £7.5.6 to £7.7.6 per 75-pound flask.

London, Aug. 5, 1905.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

ELECTRIC FURNACES.

Electric Furnace.—F. A. J. FitzGerald and P. McN. Bennie, 792,255, June 13. Application filed Dec. 3, 1904.

The furnace chamber, shown in Fig. 1, is divided into any desired number of independent compartments 9, 10, separated

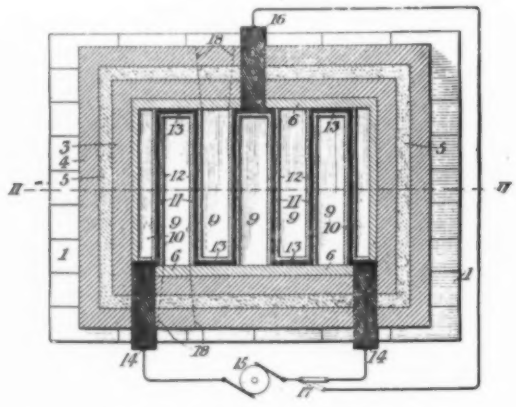


FIG. 1.—ELECTRIC RESISTANCE FURNACE.

by refractory walls. These walls comprise resistors 11 and refractory facings 12 which may be of the same character as the lining 6. The several resistors 11 are connected electrically in series by resistors 13 placed at opposite ends of adjacent compartments. The principal terminals are at 14, while 16 is an auxiliary terminal.

Producing Tungsten Steel.—E. D. Kendall, 795,517, July 25. Application filed May 31, 1905.

Concentrates of tungsten ore are granulated and mixed with metallic zinc dust and fragments of iron, free from carbon. The mixture is treated in an electric furnace. The escaping zinc oxide fumes are collected in an outside chamber.

Electric Furnace.—H. N. Potter (assigned to George Westinghouse), 797,747, Aug. 22. Application filed July 23, 1903.

Claim 3 is for "the method of reducing the terminal voltage of a conducting gap, which consists in subjecting the said gap to the influence of great heat." The inventor uses the arc gap within a resistance furnace, so that his furnace is a combination of a resistance and an arc furnace, whereby the arc may be operated at a lower voltage than would be possible without the high temperature produced by the resistance heating. "In this manner it is possible to produce a range of temperatures beginning with that reached by the unaided [resistance] furnace and ending at temperatures at least as high as those of the electric arc." A great many different applications of this principle are dealt with, especially in connection with tube furnaces, as shown, for instance, in Fig. 2, where the tube furnace 4 is supplied with electrical energy from the alternator 21 through the intermediary transformer 22, 23, while a direct-current discharge is produced over the gap 4, 5 from the battery 24. The use of a granular resistance material is brought by the inventor under the same principle: two grains make contact at one point only; the current passing through this point heats the surrounding gap of gas with a resulting leakage current across the gap. Claim 11 is for "the method of producing heat inside an electric furnace, which consists in arranging a conducting resistance and a vapor resistance, one within the other, and heating both resistances simultaneously by the passage of electric current."

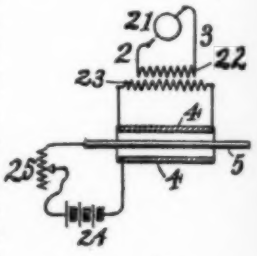


FIG. 2.—COMBINATION OF RESISTANCE AND ARC HEATING.

Electric Furnace.—C. L. Saunders, 794,255, July 11. Application filed Feb. 15, 1901.

A horizontal continuous annular trough forms a hearth which is rotated. The current is supplied through electrodes on the hearth; stationary contact pieces outside are connected with the supply circuit, and are engaged in moving contact by contact pieces on the hearth. The charge is fed at one place into the hearth, passes through the electrically heated zone and is then discharged. The gases escape through a pipe in the cover.

Apparatus for the Reduction of Iron Sand, Iron Oxide and other Suitable Substances.—D. R. S. Galbraith, 796,312, Aug. 1. Application filed Oct. 27, 1903.

"Iron sand" is first freed from all silicious matter (evidently by magnetic concentration) and then treated in the electric furnace *a* shown in Fig. 3. The charge consists of the iron sand (iron oxide) and the necessary quantity of powdered char-

coal or other reducing agent (together with a suitable flux if there is some silicious matter, etc., still mixed with the iron sand). The charge falls down upon and between tiers of carbon rods *c*, which are made incandescent by the passage of an electric current, and may be covered at the upper surface with refractory roofs. A reducing gas is introduced through *g*, and electric resistances in form of rods *i* are inserted in this passage. The reduced and molten metal accumulates in the chamber *h*. Tap holes are provided *q* for the metal and *p* for the slag.

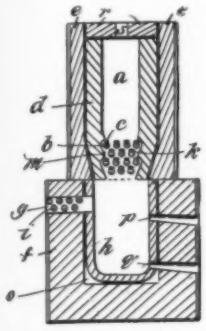


FIG. 3.—STEEL FURNACE.

Electric Oven.—L. E. Custer, 793,424, June 27. Application filed Sept. 14, 1904.

Details of construction of an electric muffle furnace for dentists. The floor and walls of the heating chamber are made of porous material, and provided with perforations or grooves in which crimped or looped wires are arranged so as to evenly distribute the heat.

ELECTROLYTIC PROCESSES.

Making Aluminium.—A. G. Betts, 795,886, Aug. 1. Application filed April 1, 1905.

The intention is to prepare pure aluminium cheaply from ores without necessitating the purification of the ore before the metal is reduced. Aluminium oxide occurs in nature for the most part associated with other oxides, notably with those of iron and silicon in clay, and with those of iron, silicon and titanium in bauxite. All these oxides are more easily reducible than alumina, so that it is not possible to prepare pure aluminium by first reducing the ore to an alloy and then slag off the impurities by oxidation analogously to the purification of pig iron and most other metals. Betts' process consists in first forming such an alloy and then refining it electrolytically.

The crude ore is reduced directly to a metallic state with or without diluting it further by the addition of another metal, as copper, zinc or tin. The product is placed in the fused state at the bottom of an electrolyzing cell and forms the anode; above it comes a specifically lighter aluminium-depositing electrolyte (*f. i.*, cryolite saturated with alumina); a layer of fused pure aluminium at the top forms the cathode. Since aluminium is most easily oxidized of the metals present in the anode, it alone dissolves and is deposited on the cathode. One of the various applications of the process given by the inventor is as follows: Clay is melted with iron ore or with metallic iron or copper to alloys of copper or iron with silicon and aluminium, the aluminium is electrolytically extracted and ferrosilicon or silicon bronze are obtained as by-products.

Another result is that in the electrolytic reduction of aluminium oxide, pure or native, a cathode of zinc, tin or aluminium bronze may be used to receive the deposited aluminium, so that a liquid alloy at a temperature below the melting point of pure aluminium is obtained. Therefore, other baths than the fluoride bath of the Hall process may be used, for instance, fused sodium-aluminium chloride. The inventor also states that aluminium can be extracted by his process from such materials as aluminium silicide and carbide and similar non-oxygen-containing compounds of aluminium.

Stopper for Electrolytic Pots Containing Fused Baths.—C. M. Hall, 796,325, Aug. 1. Application filed April 30, 1902.

The tap-hole is filled with a plastic material, composed of powdered carbon and tar, and before this becomes hard a tapering metal plug is driven inward until its end nearly reaches the interior of the pot-lining. Although the plastic material hardens and becomes baked around the plug, the latter may be readily withdrawn when it is desired to open the hole.

Electrolytically Refining Silver.—A. G. Betts, 795,887, Aug. 1. Application filed March 8, 1905.

The silver alloy forms the anode. The electrolyte contains a free, non-oxidizing, monobasic strong acid, forming a soluble silver salt, the silver salt of this acid, and a small amount of gelatin or gum-arabic, to prevent the formation of trees. The proportion of the gelatin should be between 1 to 12,000 and 1 to 15,000 of solution. A suitable solution contains 4 per cent silver, as silver methyl sulphate, and 4 per cent methyl sulphuric acid. No necessity exists for wrapping the silver anodes in cloth. The anode slime is mostly gold. The bismuth from the anode accumulates in the solution and is precipitated with hydrofluoric acid, as bismuth fluoride, or after precipitating silver—for instance, with metallic bismuth—by precipitation with metallic lead. If the latter method is adopted the resulting lead solution can be treated with finely divided silver sulphate, precipitating lead sulphate and regenerating silver solution to be used over again.

Electrolytic Decomposition of Saline Solutions.—A. B. Larchar, 793,138, June 27. Application filed Oct. 9, 1900; Oct. 9, 1902 (assigned to Penobscot Chemical Fiber Co.).

This patent is an interesting indication of the tendency of paper and pulp mills in the Eastern States to erect their own electrolytic plants for making bleach and to develop their own processes, in which diaphragm cells are generally used. The special feature of the present patent is the construction of the cathode, which is a grating of vertical slats, extending all the way around the cell along the four side walls. The steel slats are placed near together, so that the channels leading from the inside to the outside are long and thin, so as to divide the liquid passing through into thin films. On the inside a diaphragm of asbestos paper is stretched on the grating. The whole inside of the cell forms the anode compartment, and contains graphite anodes. The portion of the cell outside of the diaphragm forms the cathode compartment. Fresh brine solution is introduced into the inside compartment, and is held there at a level slightly above the outside level. The electrolyte passing through the diaphragm is divided up into a great number of films between the slats of the grating; these films are in intimate contact with the cathode surface. The caustic soda which is formed outside of the inner cell flows off through an overflow pipe, the mouth of which may be raised or lowered at will, so as to adjust the difference of the levels of the solution in the anode and cathode compartments. By adjusting this properly, it is stated to be possible to prevent the caustic soda from flowing back into the inner cell, where it would form non-desirable compounds with the chlorine. The chlorine developed in the anode compartment passes off through a pipe.

Electroplating Device.—H. Schuessler, 796,872, Aug. 8. Application filed Sept. 17, 1904.

Mechanical details of a tank for electroplating sheet-metal plates. The tank has a horizontally inclined bottom with a longitudinally movable carrier for the plate to be coated. The anode is provided above this carrier and parallel with it.

BATTERIES.

Secondary Battery.—I. Kitsee, 793,881, July 4. Application filed March 17, 1893.

According to the inventor, the change of the capacity of a battery plate for storing energy bears a certain relation to the over-oxidation of the active material. In order to restore the "vitality" of a battery plate after a certain number of charges and discharges, the inventor reduces the higher oxides to lower states of oxidation. This may be done by a very slow process of heating in dry heat in a hermetically sealed vessel, or by the application of sodium chloride to the electrode moist with sulphuric acid; or by the action of sulphurous gases, etc. Claim 1 is for "the method of restoring the usefulness of overcharged active material in secondary cells, which consists in bringing said active material into contact with a solution

adapted to in part reduce said active material to a lower oxide, and in part change the same to a salt adapted to act as binder for the particles of said lower oxide."

Battery Grid.—H. C. Porter, Waukegan, Ill. Patent 792,611, June 20, 1905. Application filed Aug. 19, 1904.

The object of the invention is the production of a plate in which the active material, or material to become active, is firmly secured against dislodgement and which is prevented from buckling. As shown in elevation and vertical section along line *zz* in Fig. 4, the grid consists of a supporting body

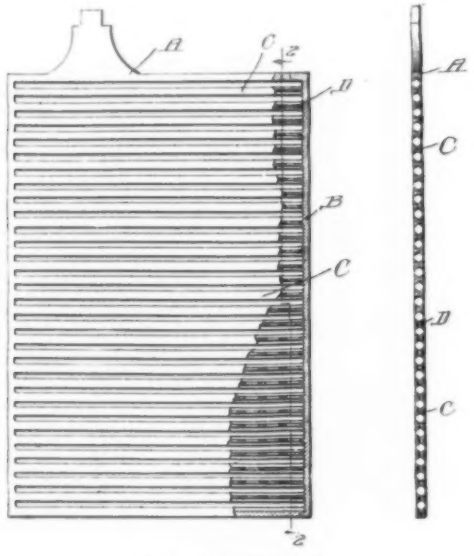


FIG. 4.—BATTERY GRID.

A, constructed with solid edges B. It is made up of a series of interior horizontal bars C, which are shown V-shaped on their upper and lower faces. The bars are provided at intervals with vertical openings D, preferably corresponding in the different bars in the same vertical plane. This method of construction is stated to provide, in addition to the metallic grid, solid columns of active material, or material to become active, forming, as it were, a supplemental grid of active material.

Battery Plate Separator.—H. C. Porter, Waukegan, Ill. Patent 792,612, June 20, 1905. Application filed Aug. 19, 1904.

The separator consists of a perforated sheet, preferably made of celluloid or hard rubber. It is provided with a series of loops, formed by two horizontal parallel cuts in the sheet, the cut portion having been bent outwardly, so as to form these loops, through which strengthening and stiffening rods can be inserted. By interposing these sheets between the electrodes the latter are not only separated from each other but are also kept out of contact with the separating sheet itself, inasmuch as they rest upon the above-mentioned rods. Cheapness of construction and durability are claimed for this separator.

Battery Grid.—H. C. Porter, Waukegan, Ill. Patent 792,613, June 20, 1905. Application filed Aug. 19, 1904.

The grid is made up of a body which constitutes the support for the active material, and is constructed with solid edges. It consists of a series of longitudinal triangular bars, which shape, however, is not essential. These bars are integrally attached to a back plate D, which is provided with a plurality of openings E. The latter have been formed after casting in such a manner that tongs are formed on the interior side of the back plate, so as to hold the material securely in place.

Galvanic Battery.—B. J. Blameuser, Chicago, Ill. Patent 792,191, June 13, 1905. Application filed Aug. 1, 1904.

The cell belongs to the carbon-zinc type, with a solution of sulphuric acid and potassium bicarbonate depolarizer. The specification describes at length various details of construction, in order to provide a more compact and simpler construction than the ordinary type.

Storage Battery.—G. K. Hartung, 797,110, Aug. 15. Application filed April 30, 1904.

In order to avoid metallic grids for the support of active material, he places the active mass in non-conducting acid-proof expansible tubes suitably mounted in frames. Carbon rods are embedded in the active mass to conduct the current to the terminals. The tubes are made of perforated, corrugated, thin celluloid.

Secondary Battery.—J. Langelaan (assigned to Pflueger Accum. Werke A. G.) 796,435, Aug. 8. Application filed Feb. 27, 1905.

Mechanical details of construction of plates of active mass, which are composed of single pieces and held together by a protective envelope. The main features are: first, horizontal supports with flanges, and second, connecting pieces which engage between the flanges of the supports upon the bent parts of the protective envelope.

Storage Battery Grid.—M. Heisser, 794,501, July 11. Application filed July 5, 1904.

The grid is a frame with a plurality of parallel cross-bars, Z-shaped in cross-section. They form V-shaped grooves in their upper and lower faces for retaining lead oxide. The flanges of the bars are wedge-shaped and terminate in sharp edges.

Battery Grid.—H. C. Porter, 793,093, June 27. Application filed Aug. 19, 1904.

Mechanical details of construction of a grid for posted plates.

Sheet Metal for Perforated Pockets of Storage Batteries.—T. A. Edison, 797,845, Aug. 22. Application filed July 21, 1904.

In his nickel-iron battery the active masses are embedded within pockets of perforated nickel-plated steel. The pocket walls must be so thick that any change in the active mass during use will fall within the elastic limits of the sheet metal. However, if the thickness of the steel is chosen accordingly, it cannot be practically perforated with the desired fineness, since the dies become quickly worn out. He therefore makes the steel thinner (0.0025 inch) and the nickel-coating thicker (0.0005 to 0.00125 inch) than heretofore.

Storage Battery.—A. Meister and A. Junker, 794,240, July 11. Application filed Nov. 11, 1901.

Method of construction of a nickel electrode for use in an iron-nickel accumulator with an alkaline electrolyte. The plate is made of a large number of alternate strips of nickel and layers of pulp or other absorbing and porous material. The plate is formed as anode in a weak solution of caustic potash, containing a small quantity of phenylate against another sheet-nickel plate as dummy electrode; the anodic current density being 1 amp. per square inch.

Cathode Plate.—H. C. Hubbell, 793,078, June 27. Application filed Oct. 3, 1904.

An electrode with an active mass of silver for alkaline accumulators. A perforated foundation plate of nickelplated iron is coated on both sides with the active mass of finely divided silver; the silver extends through the perforations, and is thus held firmly to the foundation plate. Outside of the active mass of silver a layer of asbestos paper is folded around the plate, covering both sides. Around the asbestos paper is folded a strip of wire gauze of nickel-plated iron.

Cathode Plate.—H. C. Hubbell, 793,077, June 27. Application filed Oct. 3, 1904.

A nickel electrode for alkaline batteries. Hair-like nickel

fibers (produced by electrolysis at a high current density) are mixed and intermingled with an oxide of nickel, which is moistened and formed into a dough-like or pasty plastic mass. This is formed or molded by kneading into the required shape, and placed into pockets of nickel-plated iron wire gauze.

Anode Plate.—H. C. Hubbell, 793,076, June 27. Application filed Oct. 3, 1904.

A zinc plate for use in caustic potash or soda, as electrolyte. The skeleton consists of a series of transverse sheet-steel troughs, one above the other; each trough forms a U-shaped gutter containing the zinc deposit.

Negative Electrode for Primary Batteries.—D. L. Winters, 797,787, Aug. 22. Application filed Jan. 30, 1905.

The active mass of copper oxide is contained in a casing of zinc-coated perforated sheet-iron. The zinc coating is intended to "set up at once a local electrochemical action and increase the conductivity of the negative electrode and the battery-electrolyte to attain an initial efficiency of the battery in a rapid manner."

Electric Battery.—P. J. Kamperdyk, 794,864, July 18. Application filed April 2, 1904.

Mechanical details of construction of a primary cell with porous plates forming compartments, each of which contains a positive-pole electrode, while a negative-pole electrode is in the interval between each compartment and the next. Means for the support of the electrodes and for the production of circulation are provided.

Storage Battery Jar.—T. S. Witherbee, 793,117, June 27. Application filed March 12, 1904.

Details of a battery jar for automobiles.

Galvanic Battery.—D. L. Winters, 795,325, July 25. Application filed Nov. 2, 1904.

When the disintegration of the zinc plate of a primary battery has reached a predetermined stage, a local short-circuit is automatically formed in this individual cell.

Battery Holder for Automobiles.—F. Jackson, 796,517, Aug. 8. Application filed Sept. 27, 1904.

Details of construction of spark-generating battery holders. The batteries can be instantaneously connected in the spark producing circuit without the necessity of wiring them to each other.

MISCELLANEOUS.

Converting Oleic Acid into Stearic Acid.—A. de Hemptinne, 797,112, Aug. 15. Application filed Feb. 7, 1905.

Olein and like compounds are subjected to the influence of electric effluvia in an atmosphere of hydrogen, and stearic acid is formed according to the reaction $C_nH_{2n}O_2 + H_2 = C_nH_{2n}O_2$. Polymerides of stearic acid and analogous compounds having melting points more or less in the neighborhood of 69° C. are also formed, whereas olein is liquid at ordinary temperature.

Chemically Modifying Oils.—E. Meusel, 794,373, July 11. Application filed April 30, 1903.

Fatty oils are modified by treating them with nitrates in aqueous solution or other nitrogenous substances, and introducing denitrificating bacteria (such as cheese bacteria) to the mixture. They break up the nitrates to free oxygen, whereby not only does saponification take place, but also a partial oxidation of the glycerin and of the oleic acids. The modified oils are adapted for the manufacture of degras, lacquers, mordants for dyes, etc.

Manufacture of Prussic Acid.—W. Muthmann, Munich, Germany. Assignor to the Roessler & Hasslacher Chemical Co., New York. Patent 792,783, June 20, 1905. Application filed Oct. 17, 1903.

Basing his experiments upon Berthelot's observation that when powerful sparks from a Ruhmkorff coil are passed through a mixture of acetylene and nitrogen, prussic acid is produced and carbon is separated, the inventor found that the yield obtained by Berthelot, namely, one hundredth part of a gram of prussic acid in 90 minutes from 160 cc. of gas mixture, can be increased fifty times. This result is obtained when, instead of the spark from an induction coil, an electric "flame" of high voltage is used, and if the mixture of hydrocarbons and nitrogen, instead of being exploded in a bomb, is blown in the form of a constant current through the flame and the resulting reaction products are constantly removed. This process is stated to have the advantage over that of Berthelot, inasmuch as instead of the costly acetylene, ethylene or hexane, cheaper hydrocarbons can be used, such as methane and its homologues, the hydrocarbons escaping from the earth, illuminating gas, composed of essentially 2 per cent of carbon acid, 4 per cent heavy carburetted hydrogen, 8 per cent carbon monoxide, 49 per cent hydrogen, and 37 per cent methane, gases from coke works, mineral oils and products of their distillation, and also benzene, toluene, naphthalene and other products from the distillation of tar. If these hydrocarbons, or their vapors, be mixed with nitrogen, or with nitrogen and hydrogen, and the mixture be passed through a high-voltage "flame," as much prussic acid is stated to be produced as will render the process suitable for the commercial preparation of prussic acid. Hydrogen is added when heavy hydrocarbons are used which are liable to give a deposit of soot. The prussic acid may be condensed or absorbed by alkalies or saponified. One way of carrying out the process consists in passing for an hour equal parts of nitrogen and illuminating gas through an electric "flame" of 1000 volts and 0.08 amps. Four liters of the gases produce 0.75 grams of prussic acid. Another way consists in passing for one hour through the electric "flame" nitrogen saturated at the normal temperature with vapor of benzen in the proportion of nitrogen 92.1 per cent and benzene (carburetted hydrogen) 7.9 per cent. In this case eight liters of the gases are stated to give 0.48 grams of prussic acid, soot being deposited at the same time, which deposit may be prevented by the simultaneous passing of hydrogen. A similar treatment with petroleum, heated to from 35° to 40° C., is stated to yield in one hour 0.32 grams of prussic acid. Equal, and sometimes better, results are said to be obtained when nitrogen compounds, such as ammonia, are used in place of free nitrogen. It is not settled yet whether nascent hydrogen is evolved in the latter case and produces at once prussic acid, or whether the compounds of nitrogen and carbon produce intermediary products which yield prussic acid by secondary reaction. In one case, *f. e.*, two volumes of ammonia and one volume of acetylene, or ethylene, was passed through an electric "flame" of 1200 volts and 0.07 amps., the volume of the gas being in each case 400 cc., the pressure 72.5 millimeters, and the temperature 18° C. With acetylene the amount of prussic acid obtained is given as 1.23 grams, and with ethylene 0.2 grams. Other hydrocarbons may be used in place of acetylene and ethylene.

Apparatus for Treating Liquids.—L. Dion, New York. Patent 791,457, June 6, 1905. Application filed May 24, 1904.

The apparatus comprises a receptacle for the reception of the liquid, which has a contracted lower body portion and an enlarged upper globular portion. It is provided with a filter in the globular portion. The lower portion is equipped with two groups of interlocking electrodes, which are corrugated in various forms. It is, however, essential that the general directions of the corrugations extend transversely of the interior contracted body portion of the receptacle, so as to form a sinuous course between the electrodes and to insure contact of the liquid under treatment with the electrodes. The construction of the apparatus and the electrodes is described in detail. The apparatus is stated to be especially useful in the recovery of metals and other substances from the waters of mines and minerals and other springs.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Industrial Electrochemistry.

Ozone.—A very concise summary of the various processes for the production and utilization of ozone is given by A. W. Ewell in *Elec. World and Eng.*, Aug. 12. Concerning the experimental use of the Vosmaer system in Philadelphia (our Vol. II., p. 511) the following is said: "The Philadelphia plant is in the heart of the city, and successfully purifies a million gallons a day of the very polluted Schuylkill River water. It is owned by the United Water Improvement Co., which holds the American patents of Vosmaer and Lebret. One of the towers is of glass, and the process of purification may be clearly seen. Dr. Rivas, of the water department of Philadelphia, has recently made a careful test of this plant. He found that the number of bacteria was reduced from about 1,500,000 per c. c. to between 38 and 55, when 10,000 gals. were purified per hour, and that these remaining bacteria were all harmless, disease germs being totally destroyed. This selective action of ozone is very interesting and important. Such action is not found in sand filtration."

Electrolytic Alkali Co.—In *Elec. World and Eng.* of July 15 J. B. C. Kershaw gives an illustrated description of the works of the Electrolytic Alkali Co., at Middlewich, Cheshire, England. Brine is pumped directly from the company's own brine wells into the decomposing cells without the necessity for, or expense of, any intermediate separation in the solid form and re-solution in water. There are two direct-current dynamos, each giving 2000 amps. at 60 volts. The cell contains 250 cells of the Hargreaves-Bird type, two-thirds of which are kept in constant operation. The cell is 10 feet in length, 5 feet in depth and 14 inches in breadth, the narrow chamber enclosed between the two diaphragms being filled with brine and provided with a row of anodes. The two outer compartments of the cell on each side are the cathode chambers. These are supplied with steam and CO_2 gas, and the sodium carbonate which separates on the gauze cathodes is at once washed away as a solution of sodium carbonate by the condensing steam. The carbonated soda liquors from the cells are passed through a refrigerating plant in order to obtain the maximum yield of crystal soda, and the mother liquors are finally thrown away. The decomposing cells are worked in series of 14, two of these being held in reserve for cleaning and repairs. A current of 2000 amps. is the normal one for these cells, the row of 12 thus taking the electrical output of one dynamo. The e. m. f. required per cell varies from 4 to 4.5 volts; and each decomposes about 220 pounds of salt per twenty-four hours. The anodes are made up of rows of rough blocks of gas carbon, strung upon a central support of lead-copper alloy. Cement is used to cover the latter, where it is not covered by, and in close contact with, the gas-carbon. Formerly the gas-carbon blocks were simply bored through and placed upon the copper-lead supporting shaft; but now short-rounded blocks of Acheson graphite are employed to support the gas-carbon. The diaphragms last thirty to forty days in constant work, and the anodes about the same period. The following ampere-hour efficiencies of various processes for electrolysis of brine are given: Castner-Kellner, 91 per cent; Hargreaves-Bird, 80 per cent; Rhodin, 90.2; Aussigbeil ("Glocken" process), 87.5; Acker, 91.6. The watt-hour efficiencies of the same processes are 52.3, 54, 41.4, 40.9 and 54.9 respectively.

Nitric Acid from Air.—The method of S. Eyde and K. Birkeland (which was described in our Vol. II., p. 399, in the St. Louis Congress paper of Edstrom) for making nitric acid from air by electric discharges is described in *Zeit. f. Elektrochemie*, April 21, the description being essentially a translation of the French patent 335,692, of Sept. 18, 1903, which contains some details of the apparatus.

Experimental and Theoretical.

Electrolytic Rectifier.—While the electrolytic rectifier has gradually found commercial applications for various purposes (charging storage batteries, telephony, etc.), the theory of its action is still the subject of investigation and discussion. The results of a recent research are given by S. R. Cook in the May issue of the *Physical Review*. He had found in former experiments that at least from 85 to 95 per cent of the apparent resistance of the aluminium electrolytic rectifier can be accounted for as due to a counter e.m.f. His new experiments show that this counter e.m.f. completely accounts for the high apparent resistance. He offers the following theory: Whenever oxygen is the primary or secondary product of the anion, the aluminium anode is covered with a film of hydroxide, which has a very high resistance, so high, indeed, that it acts as a dielectric to the charge on the ions. This non-conducting film between the metallic aluminium and the electrolyte produces a condenser affect with the negative charge on the anions of the electrolyte. The conditions then that always exist, when a direct current is applied to an electrolytic rectifier with a well-formed aluminium anode, are as follows: When any potential less than the critical potential is applied to the electrodes there is induced an equal and opposite charge in the electrolyte next to the respective electrodes. When the current is broken there exist bound charges in the electrolyte and on the electrodes. These bound charges on the electrodes, which may be assumed to be equal to the bound charges in the electrolyte, are what produce the counter e.m.f. The curve of decay of this counter e.m.f. with time shows the rate at which these charged ions pass through the film and give up their charge to the metallic plate. When the current is reversed, the hydrogen ions pass through the film more readily than the oxygen or other negative ions, forming a gas between the metallic aluminium and the film, thus breaking away the film and exposing the metal to the charged ions. When an alternating current is applied the film acts as a semi-permeable membrane. The hydrogen atoms having less mass and greater velocity than the oxygen or other negative ions pass through much more freely than the more slowly-moving anions. The critical potential value for an electrolytic rectifier depends upon the electrolyte used and the temperature of the cell. When the critical potential has been passed the film crystallizes, and its crystallizing exposes the metallic aluminium. The crystallization continues so long as the potential is kept above the critical value.

Use of Balanced Electrodes.—W. W. Haldane Gee read a paper on this subject on July 3, before the *Faraday Society*, which is here abstracted from advance sheets. The method of ascertaining the weight of metal electrolytically deposited by directly weighing the cathode in the electrolyte instead of removing the cathode and weighing it—after washing and drying—is considered. The real weight (M) is obtained from the apparent weight (m) by the formula:

$$M = \frac{m\,D}{D - d}$$

where D is the density of the deposited metal, and d that of the electrolyte. It is shown that since D occurs both in the numerator and denominator of the expression that for most purposes it is not necessary to know the value of D with great

accuracy. In the case of copper the value of D that may be used is 8.9. An ordinary physical balance is used, and a cylindrical cathode suspended by a thin wire passing through a hole in the bottom of the balance case is counterpoised in the electrolyte. The anode also is circular and surrounds the cathode. Electrical connection is made to the cathode by a side wire whilst receiving a deposit, but is removed when the apparent increase of weight has to be ascertained. The method has been found very convenient in testing commercial types of ammeters. An accuracy of about 1 per cent can be generally obtained, and with a little care and by increasing the amount of deposit the accuracy can be brought under 0.5 per cent. In some experiments both sides of the balance may be used simultaneously when the electrochemical equivalents of metals in different combinations may be compared and current efficiencies ascertained. A number of experiments have been made with a mercury cathode and anode, the electrolyte being solutions of mercurous nitrate, or mercuric chloride mixed with potassium cyanide. The mercury cathode is enclosed within a shallow dish suspended in the electrolyte by a platinum wire. The anode is a layer of mercury at the bottom of the containing vessel. In the case of mercurous nitrate it is shown that the current efficiency as a monad is affected by the presence of mercuric and basic compounds. For good results the mercurous nitrate solution must be carefully prepared and a strong solution used. Modifications of the method are described that may be used for the purpose of finding the density of electrodeposited metals, and for studying the relative loss and gain at anode and cathode. Instead of an ordinary balance a spring balance may be substituted. The author also shows how a Nicholson's hydrometer may be used both as a cathode and as a means of finding the amount of deposit.

It is concluded that the method will be useful in the laboratory and test room as a means of rapidly arriving at results with sufficient accuracy for many commercial purposes. In the discussion, F. M. Perkin said that the drawback to the use of mercury was that only small currents could be measured therewith. What was particularly wanted was an instrument that would indicate continuously; for example, the cathode might be suspended in a helix, to which a pointer was attached, as in the Ayrton-Perry meters.

The Position of the Alkali and the Earth Alkali Metals in the Voltage Series at High Temperatures.—The relative position of the different alkali and earth alkali metals in the voltage series is of the greatest importance for the electrolytic production of these metals. There are a number of reasons why it would be preferable to deposit the metals at as low a temperature as possible. On the other hand, the molten electrolyte should have as high a fluidity as possible, since otherwise the metal deposited on the cathode tends to grow in trees over to the anode, while the surrounding electrolyte tends to solidify. The reason is that the current which, by its Joulean effect, shall maintain the electrolyte fluid will then pass no longer through the electrolyte but through the metallic tree extending from the cathode. Destruction of the apparatus, evaporation of the metal and the occurrence of undesired reactions (for instance, the solution of the deposited metal in the electrolyte) make, on the other hand, the use of a low temperature very desirable. For these reasons mixed electrolytes are preferable to pure salts, since the former have generally a lower melting point. Since the more negative metal is first deposited from a mixed solution it is of importance to know the relative position of the different metals in the voltage series at different temperatures, and it is not superfluous to emphasize that if the voltage series has been determined at a certain temperature the series of the metals may be different at another temperature. This is very well brought out in an article by H. Danneel and L. Sackem in *Zeit. f. Elektrochemie*, April 7. It appears certain that at ordinary temperature Na is more positive than Ca (metallic sodium sets hydrogen free from alcohol in spite of the very small hydrogen ion concentration; calcium does not act in this way. Further, the heat of formation of the sodium salts is higher than that of the calcium salts). If a molten bath of $CaCl_2$ + NaCl is electrolyzed at about 800° C., Na is deposited, and not Ca, while from a mixture of $CaCl_2$ + KCl we get Ca containing K. This indicates that in the voltage series Ca is at high temperatures between Na and K, while at lower temperatures Ca is more negative than Na, so that the relative position of the Na and Ca must reverse at a certain temperature. The authors describe several experiments which strengthen this view. Na is unable to precipitate Ca from its molten salts at temperatures above 800° C. At medium red-heat an Na-Ca alloy is formed, so that at this temperature the free energy of formation of the Na and Ca salts is not very different. It seems impossible to make metallic potassium from the cheaper metallic calcium. Finally, the authors mentioned that they did not succeed in precipitating metallic strontium from its chloride by means of potassium.

Electrolytic Manufacture of Fine Wires.—In *Comptes Rendus*, May 29 (abstracted in the *London Electrician* of June 23), Abraham describes experiments in which he prepared very fine and uniform wires by the partial anodic decomposition of a wire in an electrolytic tank. The diameter of the wire is measured by determining its resistance, and for this purpose it is attached to metallic rods at both ends. It hangs in the liquid, which does not touch the rods. The solution must be very dilute; the author used distilled water containing a few thousandths of its weight of copper sulphate for copper wire or silver nitrate for silver wire. The action must be slow, in order to allow time for the products of electrolysis to diffuse through the electrolyte. He used a current density of about 10 milliamperes per square cm. of surface of the wire, and this must be reduced as the wire becomes thinner. The solution of the copper wire regulates itself, since the resistance is highest at the thinnest portions of the wire.

Preparation of Diamonds.—A paper concerning the preparation of diamonds, by H. Moissan, is given in *Comptes Rendus*, January 30, and abstracted in *Zeit. f. Elektrochemie*, May 19. A meteorite containing diamonds showed the presence of iron sulphide and silicon. The author, therefore, made experiments to find whether the presence of the two elements, S and Si, is advantageous to the formation of diamonds. The method was essentially the same as that used by him before. The addition of sulphur resulted in the formation of little diamonds of the same size as those obtained without sulphur, but it seemed that the number of diamonds formed was greater.

Artificial Diamonds.—A paper, by H. W. Fischer on experiments made by him on the artificial production of diamonds in the electric furnace by heating to a temperature of 2500° or 2800° C., or even more, and then suddenly releasing the matrix into a cooling apparatus, is given in *Elec. World and Eng.*, of May 6. The construction of the electric furnace is illustrated and several micrographs are reproduced.

Electrolytic Oxidation of Ammonia to Nitrite.—In a paper, printed in *Chem. Soc. Trans.*, Vol. 87, p. 198, and abstracted in *Jour. Soc'y Chem. Ind.*, March 31, H. D. Law gives an account of an investigation of the electrolytic oxidation of formaldehyde, acetaldehyde, propaldehyde and iso-butaldehyde in sulphuric acid solution with platinum electrodes. The chief products were the corresponding acids, together with smaller quantities of carbon dioxide and carbon monoxide.

Electrolytic Oxidation of Ammonia to Nitrite.—In a paper, published in *Berichte*, 1905, Vol. 38, p. 778, and abstracted in *Jour. Soc'y Chem. Ind.*, March 31, E. Mueller and F. Spitzer describe experiments in which they repeated former ones of Traube and Biltz, and obtained different results. They were able to get higher yields of nitrite; under any circumstances, however, the cost of nitrite thus prepared will probably be too great to allow of the process being used industrially. The gases evolved during electrolysis consisted almost entirely of

nitrogen, with a little oxygen when the nitrate concentration was high; no nitorgen oxides were observed. In neutral or very slightly alkaline solutions a certain amount of nitrogen was evolved, as the result of non-electrolytic decomposition of ammonium nitrite. W. Traube replies in *Berichte*, Vol. 38, p. 828. An ammoniacal copper solution containing fixed alkali absorbs atmospheric oxygen much more rapidly than one without it. By increasing the initial concentrations of fixed alkali and of ammonia, more concentrated solutions of nitrite can be obtained before the formation of nitrate from the nitrite begins to occur. By the electrolysis of a solution of ammonia and fixed alkali in presence of copper, containing, to start with, 11 per cent of sodium nitrite, the nitrite concentration could be increased to 17 per cent.

Electrolytic Oxidation of Organic Compounds.—A paper presented by H. D. Low and F. Mollwo Perkin, on July 3, before the *Faraday Society*, has the title: "The Electrolytic Oxidation of Hydrocarbons of the Benzene Series"; part II., "Ethyl Benzene, Cumene and Cymene." The authors have already shown that when hydrocarbons of the benzene series are electrolytically oxidized, that the aldehyde is in all cases the main product. This, however, is only the case when an appropriate solvent is employed; the only one which has given satisfactory results is acetone. In continuation of the research the authors now show that when ethyl benzene is oxidized the chief product is the secondary alcohol, small quantities of the primary alcohol also being produced. Acetophenone, the second oxidation product, is not obtained, but benzaldehyde is produced when the oxidation is sufficiently prolonged. With cumene the primary alcohol and the corresponding aldehyde are produced. The isopropyl group in cumene, however, shows itself relatively stable towards electrolytic oxidation. Cymene gives chiefly cumic alcohol and cunic aldehyde, the methyl group in the paraposition to the isopropyl group being attached in preference to the latter. In discussing the results the authors consider that the hydroxyl ion or discharge is the oxidizing agent; in other words, the oxidation is mainly a primary reaction. The work is being continued.

Electrochemical Reactions in Organic Chemistry.—The conclusion of J. Moeller's serial on this subject is found in *Elektrochem. Zeit.*, June. The chapter on the electrochemical reduction of nitrocomopnds is concluded. The author then discusses electrochemical substitution processes, and finally deals with the synthesis of organic compounds by silent discharges and with the use of electric arcs, or of incandescent filaments on gases and vapors of organic liquids.

Organic Electrochemistry.—Those interested in the applications of electrochemical methods to organic chemistry may be referred to a useful review of recent papers in this field, published in *Zeit. f. Elektrochemie*, May 5, where quite a number of papers are abstracted under the following headings: Electrolysis of Organic Compounds, Electrochemical Reductions, Electrochemical Oxidations, Other Applications of the Electric Current in the Field of Organic Chemistry.

Electrolytic Formation of Chlorate.—With respect to this subject experiments of H. Sirk, *Zeit. f. Elektrochemie*, April 28, are interesting. They show that the reaction

$$ClO_3' + 2H' + 2Cl' = OCl' + 2HOCl$$

is accelerated by platinum as contact substance; platinized platinum is specially effective. This fact may have importance for the commercial electrolytic manufacture of chlorate with the use of platinum electrodes.

Plating.

Electrolytic Zinc Plating Versus Hot Galvanizing.—With respect to the article of C. F. Burgess in our January issue (page 17), two articles by J. Szirmay in *Zeit. f. Elektrochemie*, June 2, are interesting. His results are the same as those of Burgess, that is, that electrolytic zinc plating is preferable to hot galvanizing for general purposes. The present author first determined the resistance against rusting of zinc-covered iron wires. His experiments were made under a glass globe containing air, into which were introduced, under pressure, sulphur dioxide and carbonic acid. The analysis of the air under his globe gave in one case 12 per cent SO_2 and 15 per cent CO_2. This represented an intendedly strong exaggeration of the conditions in the neighborhood of chimneys, locomotives, etc. Moreover, he heated and cooled the air alternately between the limits of 6° and 45° C. It was found that under such conditions wire plated with zinc by electrolysis resists to a far greater degree the mechanical deformations as well as atmospheric influences than any hot-galvanized wire, as a result of the better adherence and the greater purity of the electrolytic deposit. Similar results were obtained with other iron and steel ware coated with zinc.

Electroplating Upon Aluminium.—In a note in the June issue of the *Brass World*, the necessity of reducing the oxide film from an aluminium surface before plating is pointed out. It is recommended to sand-blast the surface.

Metal Finish.—An illustrated article by A. Fournier in the June issue of the *Brass World* deals with the production and application of the gun-metal finish. Another article deals with the production of a cheap imitation French-gray finish.

Storage Batteries.

Effect of Ammonia on Storage Battery Electrolytes.—A paper presented by R. W. Vicarey to the Faraday Society, on July 3, is intended by the author to be a *résumé* of observations and experiments referring to the deleterious effect of nitrogen compounds (especially ammonia) upon the durability, efficiency and behavior of storage batteries. It would appear that ammonia must be considered as a dangerous impurity, the total absence of which, however, cannot be absolutely insisted upon. The presence of ammonia in the surroundings or neighborhood of the cell must be carefully guarded against, and the percentage actually present in the cell must be kept as low as possible by the use of waters and acids of the purest quality.

The author points out that above certain limits of ammonia little difference is observed in the behavior of cells, but that below that limit much difference occurs. Thus experiments upon cells containing proportions of ammonia varying from 10 per cent to 0.1 per cent (7040 to 70.4 grains per gallon), the loss in capacity was 22 to 31 per cent immediately after the addition of the ammonia, whilst cells containing less than 0.1 per cent did not drop in capacity immediately, but varied intermittently from 10 to 15 per cent, finally settling at the end of eight months to a permanent loss of 15 to 22 per cent.

From the data given it appears that ammonia is very slow in its action before it makes any appreciable or apparent loss in the capacity of the cells, the average time being about twelve months, dating from the initial charge. The effects of ammonia in its various combinations appear principally in two distinct forms: (1) it causes and excessive disintegration or shedding of active material at the positive (PbO_2) plate; (2) it becomes deposited upon the negative (spongy) plate, and finally closes up the pores of the active material, thereby causing a decrease in the ampere-hour capacity or efficiency, varying from 10 to 60 per cent in about twelve months. The use of water taken from the steam boiler and termed "distilled" is mentioned as a dangerous practice that is common in central stations, etc., etc. The position of the battery and its surroundings are also touched upon. Finally, it is proposed that a series of experiments be carried out upon some cells in an attenuated atmosphere away from all manufacturing districts.

Refractory Materials.

Furnace Linings.—In our April issue we published a *Faraday Society* paper of E. Kilburn Scott, on refractory materials for furnace linings. In the following we give an account of the

discussion which followed. H. N. Dains gave some comparative analyses showing the differences between Indian, Grecian, Styrian and American magnesites. The great refractoriness of the first was due to the small amount of impurities it contained. Magnesite shrunk in the electric furnace certainly gave the most satisfactory results, and in support of this contention he quoted several striking instances. The principle use of burnt magnesite was for lining open-hearth steel furnaces, converters, rotary kilns for cement manufacture, furnace hearts, crucibles and refractory bricks. The power-consumption given by the author was incorrect, because the experiment quoted was carried out on *lightly* calcined magnesia that had been lying about and had taken up about 20 per cent of CO_2 and water. F. Gelstharp said that if a material could be found to withstand the action of tri-silicate of soda and lime at high temperatures, and at the same time would not oxidize, it would be a great boon to glassmakers. None of the materials mentioned by the author were suitable for the port-holes of tank glass furnaces. W. Murray Morrison hoped the author would furnish them with further more exact data regarding the temperatures the various refractory materials could stand, their mechanical properties and their heat conductivities. Tar was the best binder to use for high temperatures, and the increase of conductivity it caused was unimportant; but something that would help the refractoriness of the material would be preferable. L. Gaster said that a siloxicon wash was insufficient for lining cement kilns, for example, hard bricks of the material were necessary. R. Cremer found, after much experience, that silicate of soda was a perfect binder for carborundum. He considered carborundum as good a refractory material as any that had been described, and its mechanical properties were excellent. R. S. Hutton said that if magnesite were calcined in an electric furnace the CO_2 given off would rapidly consume the electrodes. But there was another "shrinking" in the sense of increasing the specific gravity, and to this true shrinkage the valuable properties of magnesite (as of quartz) were due; this was best effected by fusion in an arc furnace, and Moissan had obtained a magnesite of specific gravity 3.654 in this way. In the author's experiments the magnesite was never more than in a semi-plastic condition; magnesia was easily melted in the electric furnace at something above 2000° C. Electric furnaces, contrary to what had been said, did not require such highly refractory linings as ordinary furnaces, because the material itself should be the effective lining.

IRON AND STEEL.

Dry-Air Blast.—Mr. James Gayley has followed his famous first dry-blast paper with another of a supplementary nature, additional records being supplied of the working of the Isabella furnaces from November, 1904, to March, 1905. The paper is published in the July issue of the *Bi-monthly Bulletin* of the American Institute Mining Engineers. The results are best expressed in the following summarized table:

MONTH.	Average Grains of Moisture in Atmosphere Normal Blast	Average Grains of Moisture in Dry-Air Blast.	Average Daily Production.		Average Coke Consumption.		Blowing Engine. Revs. Per Minute.		Average Temperature.	
			Dry Air. Tons.	Natural Air. Tons.	Dry Air. Lbs.	Natural Air. Lbs.	Dry Air.	Natural Air.	Dry Air.	Natural Air.
November	1.99	1.02	447	386	1,816	2,279	96	111	854	750
December	1.44	0.93	455	*400	1,823	*2,309	96	*111	877	*785
January	1.245	0.635	†430	†412	†1,945	†2,346	†96	†111	†836	†744
February	1.18	0.60	412	424	1,815	2,248	96	111	800	784
March	2.25	0.95	405	411	1,837	2,274	96	111	784	850

* Average for normal blast for Dec. 1–21 only. † Average for two furnaces, each working for part of month on dry, and part on natural air, owing to a change over between furnace No. 1 and Furnace No. 3.

The above figures require very little explanation, save that the reason for the lower output for the dry-air furnace in February is due to several stoppages of the furnace using dry air on account of breakdowns of slag machine and breakouts of iron at the hearth. Notwithstanding the low content of moisture in the normal blast, the furnace equipped with the dry blast consumed 433 pounds less coke per ton of iron with a nearly equal output. As the summer season approaches the product of the furnace using normal blast will, Mr. Gayley asserts, steadily decrease and the fuel increase, while the work of the furnace using dry air will continue practically uniform.

COPPER.

The Copper Queen Smelter.—A short description of the reduction works of the Copper Queen Consolidated Mining Co. at Douglas, Ariz., appears in the *Engineering and Mining Journal* of Aug. 5. The method of bedding down the charges for the blast furnaces is stated to be a radical innovation. The ore from the Copper Queen mines is received in side-dump steel cars, which discharge into stone-lined pits. The ores are bedded in layers and the flux is added in the proper amount so as to make up the smelting mixture. This mixture is loaded by steam shovels into charge cars, trains of which are then run up an incline direct to the furnaces. It is stated that after the operation of this system of charging had been perfected there was no difficulty in making the furnaces run so as to yield slags of the calculated composition. The cars which take the ores from the bedding trenches to the furnaces are of rolling side-dump type, and discharge directly into the furnaces. Three 60-foot electric cranes of 60-ton capacity transfer the matte from the furnaces to the converter and the converter shells from the relining floor to the converter stands. The furnace and converter building are 650 x 150 feet, and contain eight blast furnaces and seven stands of converters of the trough type. A relining plant is located at each end, with stands for relining and drying thirty shells.

Treatment of Low-Grade Copper Ores.—In this country, and especially in the East, occur great deposits of sandstone of various geological ages which contain a certain amount of copper, either as metal or a sulphide or carbonate. Owing to their poor grade these deposits are not utilized, as the present methods for dealing with such low-grade ores, that is, the leaching and precipitation of the copper, either by chemical methods or by electrolysis, is too expensive for the metal values contained in them. In a paper before the Franklin Institute, published in the Aug., 1905, issue of the *Journal* of the Institute, Dr. N. S. Keith proposes a new method for the metallurgical treatment of these ores. It is based essentially upon a reducing treatment of them in a shaft furnace with the production of small globules of metal to be afterwards separated by concentration. As the gangue of these ores is preeminently selicious, inasmuch as they contain up to 90 per cent of silica, this operation can be performed without changing the silica to any extent, as there is no fluxing material of any account present. He proposes to smelt the ores in a vertical shaft furnace about 25 feet high. It is to be constructed of red brick with a firebrick lining. The powdered rock, powdered coal and producer gas, or a like fuel, are introduced from the top. The bottom of the interior of the shaft slants at an angle of

about 45° and extends into a dust-collecting chamber, which in its turn connects with another vertical shaft. This latter has also an inclined bottom, which, however, dips towards the other incline. The interior of this latter shaft is built up with pieces of coke or small stones, over which water flows, distributed by a sprinkler near the top. The draft is downward in the first shaft and upwards in the second and is produced by an exhaust fan. The treatment of the rock as it comes from the mine consists in crushing and pulverizing it to a sufficiently fine mesh, so that the particles of rock and mineral are no longer coherent. This comminution may be as fine as 60-mesh or finer or coarser as required. During the comminution about 3 per cent of the weight of the rock of finely pulverized coal is added and intimately mixed with the rock. This mixture is continually fed into the top of the furnace, and the metalliferous particles are reduced in the lower part of the furnace to metallic globules. The heat does not fuse the silica or the lime, and the result of the smelting operation is, therefore, a sand carrying minute globular particles of copper, gold and silver. The dust and condensible gases are collected on the wetted surfaces of the coke in the condensing shaft and carried to the bottom. There the water also meets the sand and carries it in a constant stream out of the furnace upon concentrators, where the metallic particles are separated out. The latter are then dried and melted and cast into merchantable shapes. The process is claimed to be automatic and cheap, under the economic conditions of the above mentioned localities, not exceeding a cost of $1 per ton on a scale of treatment of 100 to 200 tons per day of twenty-four hours. The gas drawn from the furnace is a combustible one and may be used for heating purposes.

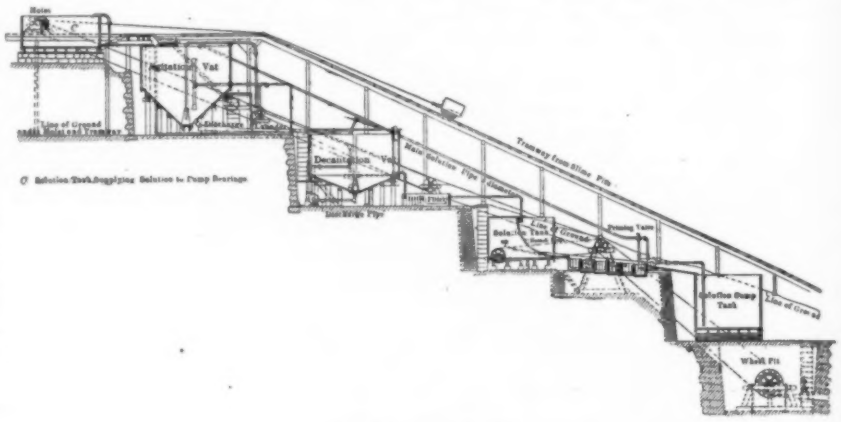


FIG. 2.—SLIME PLANT.

Gold and Silver.

Tavener's Process for Treating the Cyanide Clean Up.—It has always been a somewhat debated question whether the losses by volatilization of gold in the gases drawn from a pan furnace were of sufficient amount to be taken into consideration. In order to determine this point the metallurgical department of Messrs. H. Eckstein & Co., at the Ferreira Gold Mine in the Transvaal, determined to erect a bag-house in order to filter the gases drawn from the pan furnace. The Tavener process at these works was worked for six months,

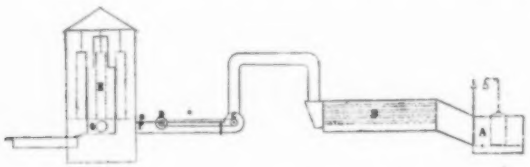


FIG. 1.—PLANT FOR COLLECTING FUMES.

and the whole length of the pan furnace culvert was cleaned up. It yielded 880 pounds of flue dust, containing only 1.71 ounces of fine gold, while during this period 16,342 ounces of fine gold had been reduced from gold zinc slime in the furnace and had been tapped in the form of lead bullion. The arrangement for collecting the fumes, described by H. Rusden in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, April, 1905, and illustrated in Fig. 1, was as follows The furnace gases passed a baffle chamber *A* and were aspirated through the tubes of an old boiler *B*, around which water was circulated to cool them. An aspirating fan *C*, driven by the motor *D*, forced the cooled gases into a brick chamber, which was surmounted by the flannel bags *E*. Experiments were tried on the test furnace as well as on the pan furnace. In the test furnace experiments nine bags were fixed in the bag house, and the fan was run at 1750 revolutions per minute. The dust collected in this case assayed 5 dwt. fine gold and 42 dwt. silver per ton. With the same conditions as in this furnace the pan furnace could not be made to work; a larger fan had to be installed and an additional water tower *G* had to be erected for passing the gases out through a heavy spray of water. The cyanide works clean-up was then smelted in three charges, twenty-four hours being consumed for smelting. The estimate of fine gold contained in the lead bullion in this run was 1,229.97 ounces. The weight of the dust caught in the bag-house amounted to 70 pounds, while that caught in the settling tank from the water tower was only 5 pounds. The assayed value of the dust was 38 dwt. fine gold per ton. It was, therefore, proven that practically no gold was carried over from the test furnace and very little from the pan furnace, if the charging is done in a careful manner.

Cyaniding Silver-Gold Ores.—The cyaniding of unroasted silver lead ores has only been commercially successful within the last few years, and a paper on the subject of cyaniding silver-gold ores at the Palmarejo Mine, read before the American Institute of Mining Engineers by T. H. Oxnam, and published in the *Bi-Monthly Bulletin* of the Institute in July, 1905, is therefore of considerable interest. The author goes quite into details in the discussion of the cyaniding process as used on the ores furnished by the Palmarejo mines, the main value of which is in silver. The major portion of the latter occurs in the form of argentite, with a small amount of stephanite, chlorobromide and native silver. He first describes the old method of crushing, roasting and pan amalgamation, which did not prove successful in this case, as the losses were too heavy. The present system of milling consists in crushing the ore by crushers and stamps, the pulp passing over ten Wilfley concentrators, which, during the year ending July 1 1904, removed about 0.76 per cent by weight of the ore and formed concentrates which contained 17.98 per cent of the silver values and 18.28 per cent of the gold values of the ore. The sands are separately treated in a cyanide plant, which consists of twelve cyanide leaching vats, each of which is 30 feet in diameter and 4.5 feet deep, and is charged with an equivalent of 100 tons of dry sand. While being trammed to the leaching vats slaked lime is added, usually in the proportion of 4 to 5 pounds of lime per ton. The treatment of the vat is

begun with weak solution carrying about 0.25 to 0.30 per cent of cyanide, in which the material is allowed to soak; weak solution being added from the top as rapidly as permitted by the leaching rate of the charge until a total of 100 to 130 tons has been applied. From 60 to 70 tons of strong solution, carrying between 0.75 and 0.80 per cent KCY, is then added and percolates through the charge in about forty-eight hours. A weak solution is then run through again as rapidly as possible, followed by a final wash of water. A thorough oxidizing of the charge is very essential for the treatment of those ores, and therefore as many charges as possible are transferred from one bath to another during the process. The solution from the leaching vats finally reaches the zinc boxes, of which there are six, five being used for the weak solution and one for the strong solution. During the year 1904, 91,793 tons of weak and 32,251 tons of strong solution passed through the boxes, an average of 251 tons of weak and 61 tons of strong solution every twenty-four hours. The five weak solution boxes are 2 feet wide and 18 feet long over all; the boxes contain eight compartments, each of which has an available zinc capacity of 24 x 24 x 18 inches. The strong solution zinc box consists of seven individual round boxes placed in series, each being 28 inches in diameter and 24 inches deep, with an available zinc capacity of approximately 5 cubic feet. The average assay values per ton of solution entering the zinc boxes are about $1.00 of gold and 2.25 ounces of silver for the weak solution, and $1.24 of gold and 3.5 ounces of silver for the strong solution. The precipitation of gold, as a rule, is practically perfect and that of the silver averages about 95 per cent. During 1904 the assay returns of the cyanide precipitate have averaged slightly over 20,000 ounces of silver and approximately $8,000 of gold per short ton, equaling about 68.67 per cent of silver 1.33 per cent of gold. The consumption per ton of sands cyanided was sodium cyanide, 2.95 pounds; zinc, 0.96 pounds, and lime 4.33 pounds. The treatment of slimes is performed in an entirely separate plant, a section of which is given in Fig. 2. The treatment consists briefly in giving the slimes about two days agitation in the agitating vats, with from two to three times their weight of cyanide solution, followed by another two, or sometimes three, days treatment in the decantation vats, during which latter portion of the treatment the charge, after having been sufficiently agitated with the addition of slacked lime, is allowed to settle as much as practicable, and the supernatant clear liquor is decanted and passed through the zinc boxes. This operation is repeated, there being ordinarily three or four decantations.

The agitation as well as the decantation vats are run by centrifugal pumps, each vat having its own individual pump. The precipitates recovered are of a lower grade than those obtained in the sand plant, because a certain quantity of suspended slimes is carried over into the zinc boxes and settles there, thus lowering the grade of precipitates. The highest grade of precipitates yet recovered from the slime plant assayed approximately $6,800 of gold and 17,300 ounces of silver per ton. The average extraction of the silver for the last three months has been 51 per cent.

RECENT METALLURGICAL PATENTS.

IRON AND STEEL.

H. H. Campbell (795,193, July 18) treats chromiferous iron for the extraction of the chromium as follows: Chromiferous iron ore is melted in a blast furnace and the molten chromiferous iron is charged, together with lime, into a basic Bessemer converter. Silicon and carbon are removed by being oxidized by the air blast that is driven through the charge, and this blowing process is further prolonged until the chromium contained in the iron is oxidized and becomes part of the slag. In order to prevent its return from the slag to the metal it is necessary to separate the metal and slag before recarburization, meaning by "recarburization" any process for removing oxygen from the blown metal or incorporating with it manganese, carbon or other elements usually deemed necessary in steel after decarburization of the iron. If the dechromized metal contains considerable oxygen it is charged into a second acid-lined converter together with a charge of iron free from chromium but with a higher carbon content (usually low phosphorus quality of iron commonly used in the Bessemer process). The inventor states that the raw iron which he has treated by this process had a content of chromium varying from 1 to 5 per cent. In one charge the iron contained 2½ per cent chromium. After removal from the basic converter the chromium content had been reduced to one-tenth per cent. This same decarburized product was then transferred to an acid-lined converter and 25 per cent of melted iron free from chromium was added. The mixture was then blown and recarburized. The finished steel contained only 0.08 per cent chromium.

Pyritic cinder, obtained from the manufacture of sulphuric acid from iron pyrites, contains such an amount of sulphur as to be considered unsuitable for making iron. T. C. King (794,673, July 11) treats the pyritic cinder with a binding material like tar or pitch, which has a two-fold action: first, to regulate the size of the nodules produced; second, to combine with the impurities (sulphur, etc.) and form volatile products. This binding material is cohesive at lower temperatures and volatilizes at higher temperatures. In the lower zones of heat in the apparatus or kiln the materials cohere by the adhesiveness of the pitch until by agitation nodules are formed, which are carried into and through the zones of incipient fusion. Here they are rendered permanently cohesive, while the impurities form volatile products and escape. The addition of 1 per cent of pitch to 99 per cent of an iron oxide, analyzing 67 per cent iron and 1 per cent silica, produces nodules about the size of a goose egg, which is best adapted to open-hearth practice, while the addition of ½ per cent of pitch to 99½ per cent of the same iron ore produces nodules the size of a partridge egg, which is best adapted to blast furnace practice.

T. Rouse and H. Cohn (797,150, Aug. 15) make briquets of powdered ferruginous matter, iron waste, etc., by using the following binding solution. One part by weight of alum is dissolved in 200 by weight of water, and 2 measures of water glass are added to every 100 measures of such alum solution, and about 1 part by weight of this solution is absorbed in the mixing process by 20 parts by weight of the powdered concentrated ferruginous matter.

ZINC.

W. Stewart (794,198, July 11) patents the following process of treating complex or refractory ores containing zinc together with gold and silver. The ore is pulverized and mixed with bisulphate of soda and with common salt, and this mixture is brought in a furnace to red heat and maintained thereat with a limited supply of air for about from fifteen minutes to three hours. The zinc is thereby brought into the condition of salts soluble in water or in slightly acidulated water. This is, of course, followed by leaching and by precipitation of the zinc salts.

E. C. Hegeler (794,799, July 18) patents details of construction of zinc smelting furnaces with a long flue-like horizontal retort chamber. The main point of his invention is that the resistance of the movement of the gases through this chamber can be reduced and the uniformity of the heating of the retorts can be improved by providing open space under the roof of the chamber and under the lowermost tier of retorts. For this purpose the retort chamber is provided with a series of recesses above and below the retorts, the recesses being staggered in the bottom and top rather than arranged opposite one another.

Gold.

F. C. Brown (791,872, June 6) patents an agitator for the mixing of sands and slimes with cyanide solution, without any revolving arms or the like, by the single agent of compressed air. The agitator, as shown in Fig. 1, is a cylindrical vertical tank with a conical bottom. The tank is filled with sands and slimes, which are allowed to settle. After the withdrawal of the top liquid sufficient space is left for the subsequent solution and the washes required. Cyanide solution is then introduced to the tank through the pipe *C* supplying the circular pipe *G* (which is indicated in the cross-section figure by two small circles only). From this circular pipe *G* the cyanide solution discharges through jets G^1. The solution is allowed to flow into the tank until it has risen nearly to the top of the central pipe *B*. Compressed air is then admitted to this central pipe *B* through the tube *F* in the bottom, with the result that a mixture of sand, solution and air rises through and is discharged through the top of the central pipe *B*. The solution, or liquid, issuing from the circular pipe *G* through the small pipes, spouts or nozzles or other devices G^1 impinges in the sides or walls of the lower conical part of the tank and causes the body of the sand or like material in the tank to settle down, the whole charge becoming a homogeneous mixture of solution and sand, as it is drawn into the bottom of the central tube or pipe, and delivered at the top of the tank so rapidly that no opportunity to settle is afforded. As soon as the surface of the mixture in the tank has risen to the top of the central pipe *B* the solution is shut off from the circular pipe *G*, and the circulation of the mixture will go on as long as required by the agency of the compressed air or gas.

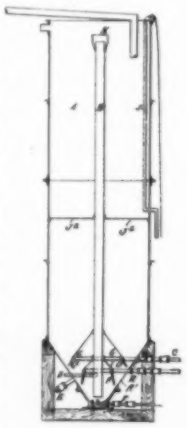


FIG. 1.—AGITATOR.

A. E. Johnson (791,424, May 30) constructs a barrel filter of lead. Lead has sufficient strength and weight to render unnecessary an additional bed or support, and it may be perforated so as to perform the filtering function itself. For this purpose the top of the filter is provided on its under surface with depressions, whereby the metal is made sufficiently thin to be perforated. The perforations are made by punching from the inside and with such a tool as to form conical orifices, smallest at the top and increasing downwardly to prevent clogging.

E. L. Godbe (793,720, July 4) patents the filter shown in Fig. 2 for separating slimes from metal-bearing solutions; 3 is a revolving drum covered with a filtering medium; the air within the drum is exhausted by means of a pipe going nearly down to the bottom of the drum (not shown in the figure) and connected to a suction pump. During the revolution of the drum the solution is sucked into the drum and the slimes adhere to the filtering surface. They are then first sprayed with a solution of cyanide through the nozzle 12, and then with water through the nozzle 13. The action of both liquids which was through the filter is to displace the metal-bearing solution from the slimes. The slimes are scraped off by means of the brush 15 and the scraper 18 and fall into the hopper 16.

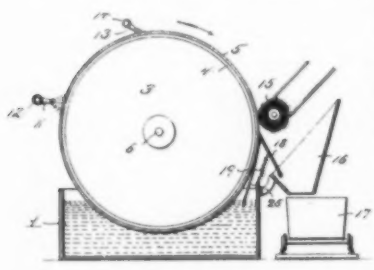


FIG. 2.—FILTER.

T. D. Jones (795,744, July 25) patents details of construction of a revolving barrel for the chlorination process. The barrel is provided at one extremity with a filter, and at its opposite extremity with a valve-controlled inlet for subjecting the contents of the barrel to pressure. For charging the barrel and for filtering the barrel is placed in upright position.

R. A. Kerr (789,325, May 9) patents details of construction of a device for treating slimes and consisting of a filtering tank and agitator. The latter consists of blades revolving on a shaft within the slimes.

BOOK REVIEWS.

Le Four Electrique, son origine, ses transformations et ses applications. By Adolphe Minet. [Libraire Scientifique, A. Hermann, Paris.] Part I. Price, $0.80.

A really satisfactory book on the electric furnace, to be used for reference purposes, is certainly needed, but so far has not appeared. Attempts have been made to produce such a book, but, unfortunately, they have not been successful, their failure being due to the lack of practical knowledge of electric furnaces on the part of the author. An enormous amount of material has been published in the shape of patents, scientific papers, and so forth, in relation to electric furnace work, and it requires no little knowledge on the part of the would-be compiler to discriminate between what is valuable and what is worthless.

Judging by the first of the proposed five numbers of Mr. Minet's "Le Four Electrique" we shall have a valuable reference book when the work is complete. The task Mr. Minet has set himself is by no means an easy one, as may be supposed, but he seems to have approached it in the proper manner and to have taken great care in the preparation of the first part.

This number contains much interesting historical matter, a classification of electric furnaces, a description of the laboratory furnaces invented and used from the year 1808 to 1886, while the remainder is occupied with various theoretical considerations, such as physical units, laws of electrolysis, etc.

In spite of the care that has evidently been exercised in preparing the work, some errors have crept in. Thus, in the classification of electric furnaces on page 11 the Ruthenburg furnace should not appear in the class "La résistance n'est pas en contact avec les matières traitées," the sub-class, "Résistance solide," and the specification "Four d'induction," but should appear in the class "La résistance est constituée par les matières traitées." In this class also should appear Acheson's graphite furnace and the original Cowles furnace. As an example of omission we find that Colby's induction furnace is not mentioned, much less described.

However, in spite of some minor errors, Mr. Minet's work is welcome, and we look forward with much interest to the next number, which will discuss the industrial electric furnaces that have been developed since 1886.

Les Fours Electriques et leurs applications industrielles. By Jean Escard. [Vve. Ch. Dunod, Paris.] Price, fcs. 18.

This work is simply in the nature of a collection of accounts of electric furnaces taken from various sources, no great discrimination being shown in the compilation. We are informed, for example, that the Conley furnace is working on a large scale for the manufacture of steel in the United States, though to the best of our knowledge the Conley furnaces have not yet been worked commercially anywhere. Errors, of which this is an example, are likely to enter into a book largely made up of information picked up from various sources, unless the collector goes to considerable trouble in verifying the material he obtains.

We conclude that considerable space is devoted to the elec-

trolytic manufacture of aluminium, because the bath is kept in the fused state by means of the electric current. If this is so it does not seem logical to omit reference to Castner's process for manufacturing sodium and Acker's process of making caustic soda and chlorine.

A great deal of the book is taken up with a description of Moissan's work with the electric furnace. For our part we much prefer studying work of that kind in the original when, as in this case, it can easily be obtained.

Some errors have been overlooked in reading the proofs, for we are told that the Pittsburgh Reduction Co. uses 1500 hp. in manufacturing aluminium in America. Probably this is a misprint for 15,000.

There are many illustrations in the book, some being very poor, as that showing the general view of Keller's furnace.

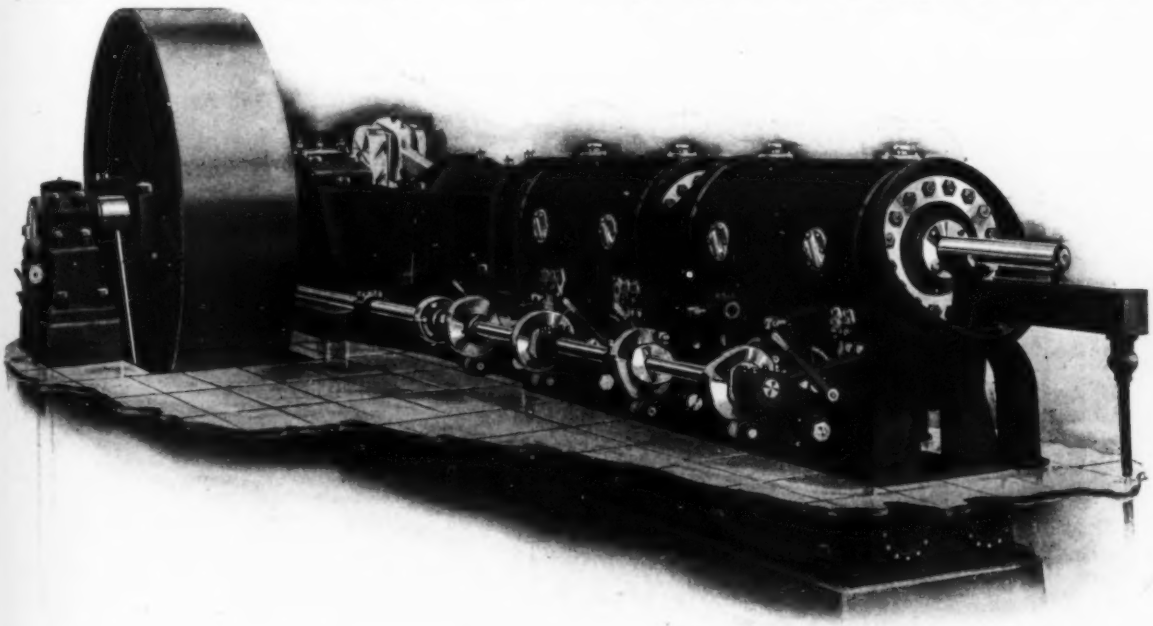


FIG. 1.—500-HP. SARGENT DOUBLE-ACTING TANDEM GAS ENGINE.

THE ELECTRIC FURNACE. By Henri Moissan, translated by A. T. de Mouilpied. [Edward Arnold, London.] Price, $2.75.

In spite of the great interest of Prof. Moissan's work on the electric furnace, the number of those interested in it is limited. It, therefore, appears to us that Prof. Moissan should not have permitted two translations in the English language to appear.

The present translation is fairly satisfactory, although the adherence to the original French is in many places too close.

Complete Expansion Gas Engine.

The Sargent engine was not only the first successful double-acting tandem gas engine, but the first and only one to expand the burning charge to practically atmospheric pressure, to vary the point of cut-off of the admission inlet with the load, and to advance the time of ignition as the mixture gets weaker and the inflammation slower. The advantages thus secured over the ordinary gas engine are: Increased efficiency, increased regularity in speed, and smooth running under early cut-offs.

The general design, as shown in Fig. 1, is not only symmetrical and pleasing to the eye, but is such that all the strains come in a straight line, yet the free expansion of the cylinders and rods is provided for. The sub-base, the top of which comes flush with the floor line, gives a flat planed surface, upon which the engine is easily erected and aligned. The sub-base and main frame are bolted to the foundation, and the cross-head guide, cylinders and distance head, which fasten to the main frame, can come and go as the temperature varies, sliding on the hollow supports rising from sub-base, which not only maintain the cylinders in line, but convey the gas and air from the hollow divided sub-base to the explosion chambers, thus doing away with the pipes, ordinarily so unsightly and in the way.

In the ordinary gas engine, the piston at full load draws in a cylinder full of combustible mixture, which after compression and ignition is expanded to the original volume and released at a pressure of 25 to 40 pounds absolute, and a temperature of from 900° to 1500° F. In the Sargent gas engine the admission of gas and air at full load is cut-off from five-eighths to three-quarters of the admission stroke, depending on the fuel used, which, after compression and ignition, is expanded to the cylinder volume and is released a little above atmospheric pressure with a corresponding temperature of about 400° F. The heavy line (Fig. 2) shows the indicator diagram of the ordinary gas engine at full load, and the light line extension

FIG. 2.—INDICATOR DIAGRAM.

FIG. 4.—DIAGRAM OF VARIABLE LOAD.

shows the increased power with the same fuel obtained from the Sargent complete expansion engine. The point of cut-off, while constant for the full and most economical load of the engine, is made earlier by the governor as the load gets lighter or later as the load gets heavier, giving a flexibility unobtainable in the ordinary internal combustion engine.

No throttling action of the incoming charge, with its corresponding loss of efficiency, so apparent in the ordinary gas engine, is possible, and owing to the more complete expansion

of the burning gases turning the heat into work instead of throwing it away in the exhaust, a lower terminal temperature, and, consequently, a lower average temperature of the cylinders is maintained throughout the cycle. For this reason engines of this type below 100 hp. require no water-cooled pistons or rods.

The mechanism of the Sargent engine is distinctively simple.

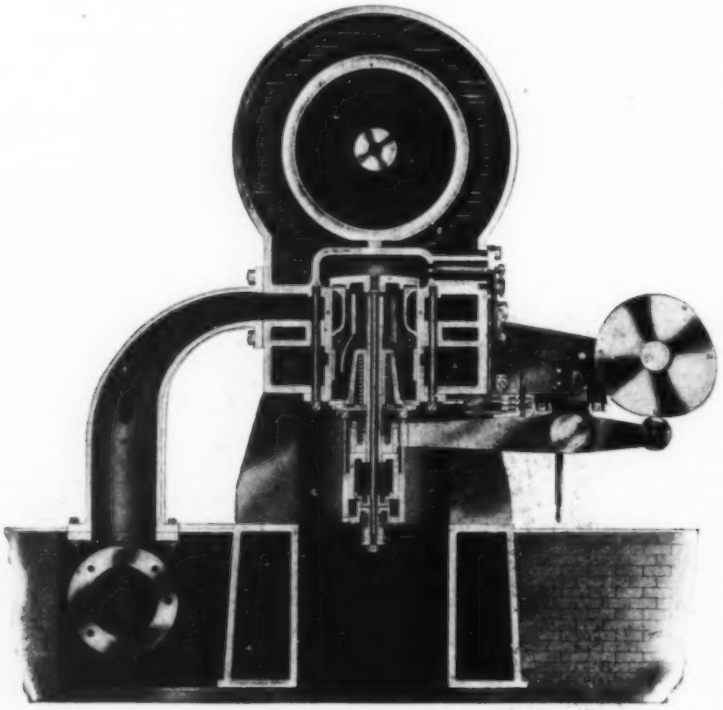


FIG. 3.—VALVE SECTION.

A side shaft, driven by the crank shaft and governor through a pair of worm gears running in oil, carrying two cams for each explosion chamber, one for the igniter and one to operate the valve, comprises all the moving mechanism except the valves and lever, as shown in Fig. 1, the other side of the engine being perfectly plain.

Fig. 3 shows a section through the valves of one of the explosion chambers. By removing six nuts, valve bushing and valves can be removed from the cylinder for regrinding or inspection.

Gas is piped to the chamber A in the sub-base and air to the chamber B, which pass through the cylinder supports to the chambers A′ and B′, ready to pass into the mixing chamber when the cam depression M N passes the roller and the ports F in the piston valve register with the ports E and D in the bushing. When the piston valve goes down to this position the confined air in the piston valve dash-pot forces open the poppet valve, thus giving free admission to the charge. When the point N of the cam reaches the roller it is forced down, while the other end of the lever goes up, carrying the piston valve, which cuts off the admission. The poppet valve seats and both valves remain in normal position during compression, ignition and expansion, or until the point L on the cam pushes the roller down and the piston up, which opens the poppet, and the exhaust gases pass out through ports K and the elbow W to the exhaust pipe under the floor.

The poppet valve seals the opening in the combustion chamber during compression and inflammation, and the piston valve, holding against no pressure, works loosely in its bushing, cutting off the admission and guiding the exhaust.

As the poppet valve controls both the inlet and outlet gases, both the valve and seat keep cool and need to be ground not over once or twice a year. The mechanism is simple, and as the roller is always bearing on the cam the valve motion is practically noiseless.

By revolving the piston valve by the index wheel, the blind port S varies the mixture to suit the gas, whether it has 100 or 1000 B. T. U. per cubic foot.

The speed of the Sargent engine is controlled by the well-known Rites inertia governor in the fly-wheel, which advances the valve shaft in time ahead of the crank shaft, as the speed increases, thus diminishing the mean effective pressure with the load. As the load gets lighter the cut-off becomes earlier, taking less of a constant mixture of gas and air into the cylinder, but as the burnt products in the clearance do not get less, the mixture gets weaker and slower burning. If the ignition were at the same point as at full load, as is the case in the ordinary gas engine, the highest pressure would not be attained till the piston approached the middle of the stroke, where the cooling surface is so increased that the greater part of the heat goes into the water-jacket rather than into the work. In the Sargent engine the time of ignition advances with the cut-off, getting earlier as the mixture gets weaker, thus maintaining the highest pressure at the begining of the stroke, irrespective of the load, as shown by Fig. 4, an actual diagram of a variable load from the Sargent gas engine.

While the governor controls the speed through all ranges of load, the gas engine, like the steam engine, is not economical with very light loads. Where a variation in the turning moment is not objectionable, one or more of the explosion chambers may be cut out at will by the engineer, by simply raising to horizontal position a controlling lever, which holds the exhaust open and the gas and air closed. This is very desirable in blowing engines, as they can be designed so that two explosion chambers will furnish air at 15 pounds and the four chambers at 30 pounds pressure.

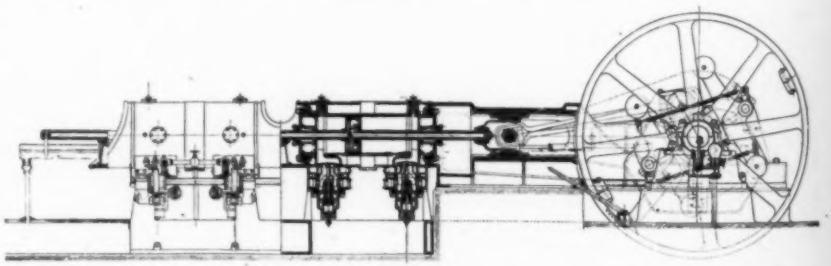


FIG. 5.—COMPLETE EXPANSION TANDEM GAS ENGINE.

If at full load the Sargent engine is cutting off at three-quarters stroke, an overload may be taken care of by a later cut, though at a decrease of efficiency.

The cylinders are oiled by a force feed-pump or check valve lubricators. The valves get sufficient oil from the cylinders.

The side shaft and out-board bearings are self-oiling. The cross-head guides, pin crank, pin and main bearings, which must be thoroughly lubricated at all times, are copiously oiled by the worm gears, which act as a pump.

Two electric ignitors are placed in each explosion chamber in such a position that they are surrounded with a pure mixture at the time of ignition. Either will fire the charge, and should either become short-circuited the engineer is immediately advised.

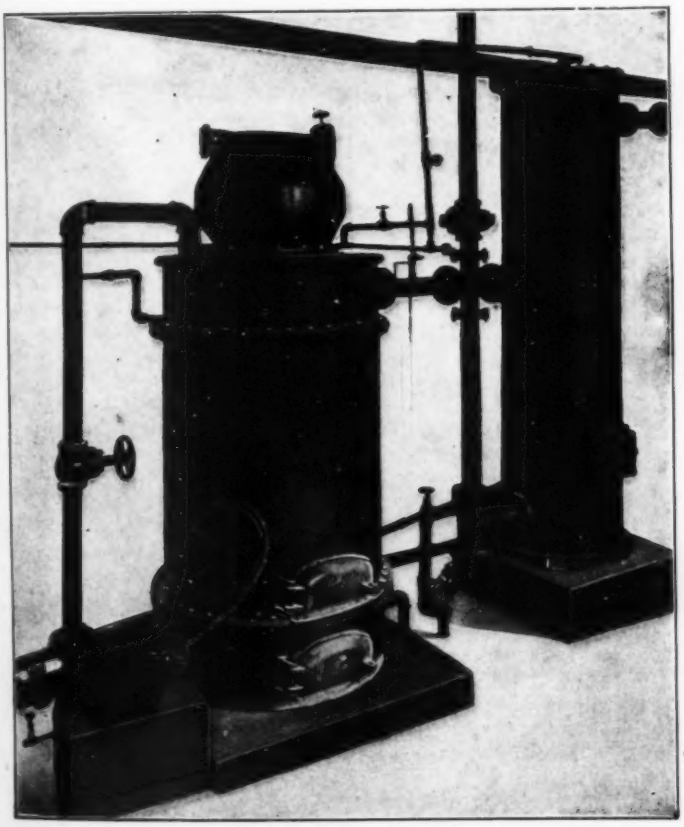
The engine is started by compressed air. The pressure of the air when turned on at one cylinder puts the starting mechanism into operation and at the same time puts the cylinder out of service as a gas engine.

When the engine is up to speed, turning off the air puts the gas engine into commission without changing a valve, cam or lever.

The Sargent engine is built by the Wellman-Seaver-Morgan Company, of Cleveland.

Suction Gas Producers.

Suction gas-producer plants are being more and more introduced with great success in this country on account of their simple working and great economy in running and maintaining expenses. They are used in connection with gas engines for developing power for all kinds of industries and shops. A



SUCTION GAS PLANT.

general discussion of suction gas producers was already given on page 432 of our Vol. II.

A suction gas producer, as shown in the cut, is now working successfully in the machine shop of the F. W. Horstmann Co., East Newark, N. J. This shop, which was using before illuminating gas in connection with a gas engine, is now using a gas producer. The plant, which was built by Dr. Oskar Nagel, of New York City, is working according to the guarantee given with the plant, that is, the development of 1 B. H. P. hour from 1¼ pounds of anthracite (pea) on full load, 1 1-3 pounds on three-fourths load, and 1½ pounds on one-half load.

The plant has a capacity of 20 hp., and consists of a hand-blower, producer with evaporator on top of same, and a scrubber, which is shown on the cut. The overflow water pot which belongs to the plant is in the pit between the producer and the scrubber, and a small equalizing tank is connected on the floor below to the engine, so as to connect the scrubber with the engine.

By the sucking action of the engine the air is drawn over the surface of hot-water in a water-jacket and saturated with steam, and this saturated mixture of steam and air is drawn through the fuel, whereby the producer gas is generated. From the producer the gas goes through the scrubber, which is filled with coke, and where it is freed from dust and tar by means of water. From the scrubber the gas goes through the equalizer, which is a simple iron drum, to the engine.

This plant is provided with a hopper, which is sufficiently large so as to contain fuel for the whole working day, so that no refilling of coal is required during the working hours. After shutting down over night the lower door is kept somewhat open and also the valve leading to the flue, so as to keep up a little draft and maintain the fire. In the morning, before starting up, the fire is cleaned from the ashes and the hopper filled with coal, and then the fire is blown hot for about ten or fifteen minutes by means of a hand-blower, until the gas is burning well at the test cock, and then the engine is started as usual.

During the working day the plant does not require any attention except cleaning the grate once or twice a day.

Pyrometer.

The improvements in the economy of working which have been realized in recent years in chemical and metallurgical industries are due to a great extent to the systematic attention which is now being paid continually during the manufacturing process to all factors which determine its efficiency. The temperature is one of the most imporant factors. In a great many cases the reaction which is desired will take place only between certain limits of temperature, and to get the best efficiency the temperature must be restricted within still narrower limits. To accomplish this in practice it is, of course, first necessary to measure the temperature exactly, while for purposes of control, etc., a continuous record of the changes of temperature is highly desirable.

The requirements of chemical and metallurgical practice have led to the design of various types of registering pyrometers, most of which have been described in these columns. It is, of course, understood that it would be wrong to consider one single type of registering instrument as the best one for all purposes, since the type to be chosen depends upon the temperature to be measured and on the conditions of the operation.

The accompanying illustration shows a very interesting new pyrometer for temperatures between 0 and 2500° C. (*i. e.*, up to about 4500° F.). The pyrometer was invented by Mr. F. de Saintignon, and is built by Messrs Richard Frères, in Paris.

The principle is extremely simple. A double metallic tube *EF* is placed in the room, or apparatus, the temperature of

which is to be measured. If water is now passed through this tube with a constant speed sufficiently high to prevent evaporation, the difference of the temperatures of the water when entering and leaving the tube indicates the desired temperature if the speed of the water is known.

The whole apparatus, shown diagrammatically in Fig. 1, consists essentially of the double metallic tube *EFG*, which is called the "explorer," and the two thermometers T^1 and T^2. The water is supplied from a reservoir in which it is held at a

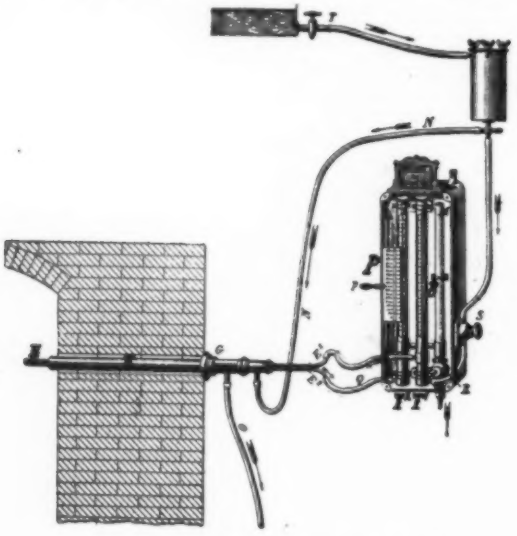


FIG. 1.—PYROMETER WITH FLOWING WATER.

constant level. One of the two thermometers T^1 and T^2 measures the temperature of the water while passing into the metallic tube, the other while passing out.

The speed of the water is regulated by means of the cock *R*, the height of the water in the manometer being held at the level *B*. In order to read the temperature it is only necessary to adjust the zero point of the scale *P* to the temperature of the incoming water. Then the temperature of the out-

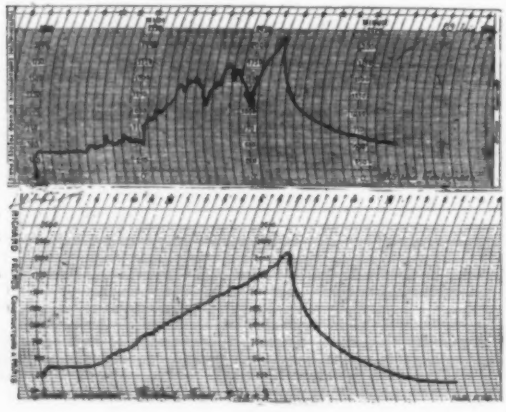


FIG. 2.—TEMPERATURE DIAGRAMS.

going water (which is now also the difference of both the temperatures) gives on scale *P* directly the desired temperature in the furnace.

The company has recently rendered the instruments self registering, and various instruments of this kind are now in successful use in France in numerous glass and china factories as well as in open-hearth furnace plants. By taking a record of the temperature during a total run it has been possible to trace sources of inefficiency and to improve the operation essentially. Fig. 2 is interesting in this respect; the upper diagram was taken when an instrument of this type was first installed in the Say refinery in Paris; it is evident that the regulation of the temperature was not at all as desired. After this had been recognized it was easy to correct this, and the result is shown in the lower diagram.

Continuous records made by recording instruments are the safest indication whether the operation is at all times being carried out under the best conditions.

The instrument described is now being introduced in this country by Mr. Ernest H. du Vivier, 16 Church Street, New York City.

Industrial Notes.

Platinum.—Messrs. Baker & Co., Inc., refiners and manufacturers of platinum, of Newark, N. J., and New York City, are making extensive additions to their Newark works. The rapidly increasing consumption of platinum in the industrial arts has made this extension necessary, especially in their refining department, which will be enlarged over 100 per cent. New and larger offices are also being erected, and the entire plant equipped with the most modern appliances for the economical manufacture of their varied and high-grade products.

New Wanner Pyrometer.—Patents have been allowed on the construction of the Wanner pyrometer for measuring temperatures ranging from 620° C. to 1000° C. This instrument supplies a means of making determinations up to that temperature at which the original high-temperature type of Wanner pyrometer begins. The new instrument embodies the same principles, and is known as the Wanner low-temperature optical pyrometer. It is particularly adapted for measuring temperatures in tempering steel, and is said to be the first pyrometer on the market especially adapted for this purpose. The instrument is well finished throughout and is easy to handle. The incandescent light used in standardizing is a 2-volt osmium lamp, thus reducing the size of the battery necessary, and making the instrument still more portable and convenient. Messrs. Eimer & Amend, of New York, are the agents in this country for the instrument.

Gold Milling in the Black Hills.—Prof. H. O. Hofman's highly interesting paper, read before the American Institute of Mining Engineers, on the methods of gold milling used in the mills of the Black Hills of Dakota, has been reprinted by the Allis-Chalmers Co. as special publication No. 4000. The pamphlet is profusely illustrated with sectional diagrams and exterior views of gold milling machinery.

Tube Mills.—An illustrated pamphlet on Krupp tube mills, with continuous feed and discharge for dry grinding of all materials, has been sent us by the American representatives, Messrs. Thos. Prosser & Son, New York.

We have received from the American Platinum Works, of Newark, N. J., a handsome and nicely finished 15-inch desk rule.

The Crocker-Wheeler Co. is in receipt of an order for a 200-kilo volt-amp., three-phase, 60-cycle, engine-type alternating-current generator for the Ivorydale (Ohio) lighting and power plant of the Proctor & Gamble Co. This machine is a duplicate of the first Crocker-Wheeler alternator ever built, which was installed ten months ago in the Atlanta plant of the Proctor & Gamble Co. The high efficiency and excellent performance of the earlier machine lead the purchaser to cancel an order for another type of generator and to order a duplicate of the first machine.

Small Motors.—Bulletin No. 60 of the Crocker-Wheeler Co. gives data on the construction of their small direct-current

motors from ¼ to 3 hp., with numerous illustrations of the application of such motors to the operation of various industrial machinery, with some elementary but useful information on electric units, the size and speed of driving and driven pulleys, the weight of belts and the carrying capacity and dimensions of wires.

NERNST LAMP.—No. 8 of the Nernst Central Station Bulletin, published by the NERNST LAMP CO., of Pittsburg, Pa., deals with "the use of the Nernst lamp as a peak broadener," by enabling special inducements to be made to desirable customers by means of a combination of a two-rate system of charging with the use of high efficiency lamps like the Nernst.

We have received from Messrs. CHAS. COOPER & CO., 194 Worth Street, New York, their monthly price list of chemicals for August. The prices are mostly given per pound or gallon; a statement which is made in various cases whether the prices are advancing or declining will be found useful.

STORAGE BATTERIES AS VOLTAGE REGULATORS.—Bulletin 2 of the NATIONAL BATTERY CO., of Buffalo, N. Y., deals with the use of storage batteries for line voltage regulation on a hydro-electric system, and describes the application of this principle on the system of the Syracuse & Suburban Railroad Co.

MOTOR CONTROL.—Circular 1108 of the WESTINGHOUSE ELECTRIC MFG. CO. gives fully illustrated descriptions of regulating and reversing controllers for direct-current motors and polyphase induction motors.

SMELTING FURNACES AND ACCESSORY EQUIPMENT.—Catalogue No. 122 of the ALLIS-CHALMERS CO. (55 pages) deals with smelting machinery. A brief introductory chapter on the metallurgical principles of smelting in general is followed by two concise and very interesting chapters on modern blast furnaces for lead smelting and for copper smelting, and shorter notes on the use of hot blast, water-jackets, forehearths, slag, matte and bullion pots, charging apparatus and blowers. The pamphlet is very fully illustrated by diagrams and views of the latest types of smelting machinery.

HOT BLAST.—We have received from Mr. GEORGE MITCHELL, 52 Wall Street, New York, a pamphlet on his economic hot-blast furnace. The well-known advantages of the use of hot blast for the smelting of many sulphide ores with a considerable reduction of the quantity of coke required, are pointed out. In the Mitchell furnace the blast is not heated by means of a separate heating stove with extra fuel, but the heat of the furnace itself is utilized. The blast is delivered from positive pressure blowers to the furnace, where it enters primary air jackets, and thence travels in a zigzag course, and is heated in its passage by direct contact with the walls of chambers; the air is then taken to the secondary air jacket, where it is again heated, and passes from there through a series of pipes to the tuyeres. Details of construction are shown in a diagram in the pamphlet. An incidental advantage is that the incoming supply of air maintains the walls of the furnace above the feed floor opening at a sufficiently low temperature to render the use of firebrick or other refractory lining unnecessary, and permits of the use of a metallic furnace section for conveying away the heated gases and unconsumed products of consumption. The pamphlet states that in the whole twenty-nine Mitchell furnaces are in successful operation or in course of erection in Mexico and Arizona.

SOME DETAILS AS TO SMELTING PRACTICE AND EQUIPMENTS.—Under this title the COLORADO IRON WORK CO. have just issued their catalogue No. 12 (157 pages), which is a very interesting and profusely illustrated discussion of modern practice and tendencies in the reduction of gold, silver, lead and copper ores. A considerable portion of the book deals with the use of hot blast; the true economy of this method is discussed in a very suggestive way. Then follow illustrations, with brief descriptions, of a great many types of modern smelting furnaces and accessory smelting machinery.

GAS POWER.—A very neat and fully illustrated pamphlet of the DE LA VERGNE MACHINE CO., of New York City, gives a detailed description of the Koerting 4-cycle gas engine, as well as illustrated notes on gas producers. The following are the results of tests of two Koerting engines, operating on gas of a calorific value of about 500 B. T. U. per cubic foot:

Engine 4,190.	R. P. M.	B. H. P.	Cubic Feet Gas per Hour.	Thermal Efficiency.
Full load.....	161	108.10	1892.9	28.22%
Two-thirds load..	165	74.27	1472.6	
One-third load...	167	37.38	987.4	
Engine 4,249.				
Full load.....	140	114.22	1902.6	31.96%
Two-thirds load..	140	76.64	1453.5	

Some illustrated notes are given on gas producers and an appendix gives useful engineering data in form of tables on tests of producer gas plants, comparative data of steam and gas plant tests, thermal and chemical data regarding combustion, characteristics of power gases, calorific values of elementary gases, conversion factors of units and comparative tables of thermometer scales.

COPPER MINING.—Some recently published data on copper mining in various districts of the United States show the most remarkable growth of this industry during the last years. While only three years ago some of the best students of the lake copper business considered 200,000,000 lbs. per year as the ultimate productive capacity of the Lake Superior mines, this figure has already been exceeded in 1904, and will be largely exceeded during 1905, barring serious accidents of an unforeseen nature. Of the important old producers the Calumet and Hecla has work under way which should result in increasing its production to approximately 100,000,000 pounds a year within the next few years. From the Butte district it is stated that there were shipped from the Washoe smelter in June more than 15,000,000 pounds of copper, and that the July shipment was but little less. As the Washoe produces little more than half the copper of the Butte district the total output was in excess of 30,000,000 for each of the two months; the production for August was lower. The Guggenheim Exploration Co., of New York, is stated to have taken the entire issue of $3,000,000 of bonds made by the Utah Copper Co., composed of Colorado Springs capitalists. Of the issue $750,000 will be applied to the redemption of a previous issue. The remainder will be applied to the construction of a 6000-ton mill at Bingham, Utah. Work will begin at once, and by spring installation of machinery will begin. In connection with the reduction works at Bingham the company will have a total capacity of 7000 tons.

EXPORTS FROM UNITED STATES.—The Department of Commerce and Labor has sent to manufacturers and exporters a circular, requesting their coöperation in the efforts being made by the department, through the Bureau of Manufacturers, to extend the foreign trade of the United States. In furtherance of this work, it is proposed to establish a comprehensive card index, which will enable the department, upon application, to furnish information desired by manufacturers, or by intending purchasers. If the necessary authority shall be granted by Congress it is contemplated to extend the system to the principal consulates. For this purpose the bureau has prepared a blank, which is to be filled out and to be returned to John M. Carson, Chief of the Bureau of Manufacturers, Washington. The information requested on the blank refers to name and address of main office, location of branch establishments, description of product, capital, capacity per day, month or year; the places where the product is sold (stating for foreign countries the ports to which it is shipped), etc. The idea is undoubtedly an excellent one, and the information contained in such a card index should prove extremely valuable in future, if our manufacturers comply with the request for information made by the department.

Obituary.

John Herbert Bagg, secretary of the General Chemical Co., died Aug. 16 at his residence at Bay Ridge, N. Y., aged 37 years, of typhoid fever. Mr. Bagg was born near Brockville, Ontario, and was educated there. He became connected with the Brockville Chemical Works in 1888, and moved to New York in Feb., 1889; since that time he has been actively identified with the chemical industries, first in connection with the Nichols Chemical Co. and later with the interests consolidated in the General Chemical Co. In a resolution adopted by the board of directors of the General Chemical Co., and expressing their profound sorrow at Mr. Bagg's death, it is said that "by his unusual sagacity, his devotion to duty, his loyalty and high standard of honor, Mr. Bagg earned the unbounded respect and confidence of his business associates; while his pure and irreproachable life, his sturdy manhood, his generous impulses, his amiable and sympathetic nature, won the love and esteem of all with whom he came in contact." Mr. Bagg was married to Miss Mary Christine Carter, of Baltimore, and leaves besides his widow a young son.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Electric Smelting and Reduction Processes.

(*Continued.*)

No. 614,927, Nov. 29, 1898, George D. Burton, Boston, Mass.

Roasts and reduces ores containing sulphur, arsenic, antimony, zinc, lead, etc., in a resistance furnace. The furnace is a vertical cylindrical chamber having walls of electrically non-conducting material glazed inside and out with a mixture of clay, 5 pounds; sodium chloride, 2 pounds; borax, 1 pound, and glass, 1 pound. The resistor is a perforated central pipe with a wide, hollow, spiral flange, perforated at the periphery, consisting of an alloy of copper, 3 parts; antimony, 1 part, and tin, 1 part. The ends extend through the top and bottom of the furnace and are connected to the terminals of an electric generator giving 8000 to 12,000 amps. at 8 to 50 volts. The resistor is mounted to rotate, to stir the charge when necessary. The furnace cover has a charging opening and a gas outlet leading to a valved horizontal flue containing baffles, the end of which dips into a tank of water. The ends of horseshoe magnets may extend into the flue, to retain magnetic particles. The furnace has a drop-bottom, with tap-hole. Valved pipes are connected to the upper and lower ends of the resistor. In using the furnace, the ore may be mixed with charcoal, coke, carbon dust, lime, a flux, etc. As the ore is heated, "obnoxious gases" and "moist vapors" are eliminated and pass through the openings in the resistor and out through its ends. The heat is then increased and arsenic and sulphur pass into the flue, wherein they are deposited. Air is then admitted through the resistor, burning out the remaining sulphur. The heat is further raised until the metal of lowest fusing point is reduced, whereupon it is tapped out. Additional flux may be added, the heat is again increased and the metal of higher fusing point is reduced and tapped out. Some ores require no reducing agent. It is stated that the furnace may be used for the manufacture of calcium carbide, the resistor then being of carbon.

No. 626,635, June 6, 1899, Gustav Schwahn, St. Louis, Mo.

Volatilizes alumina or aluminium fluoride or chloride, and reduces the vapor by incandescent carbon, carbon monoxide and fluorine, chlorine or aluminium fluoride or chloride. The alumina is volatilized by an arc; other compounds by heat of combustion. The charge may consist of the aluminous compound 98 parts, a fluoride 1 part and carbon 1 part. The reduced aluminium collects and is tapped or allowed to run out, the gaseous non-metallic compounds being led off. Four types of furnaces are shown: That for treating alumina comprises a hopper which delivers the charge through a rotating sieve into and through an arc sprung between the edges of horizontal carbon plates. The vapor passes into a horizontal reduction chamber, having walls of magnetite, calcium aluminate or fire-clay. This chamber is traversed by two grids of vertical carbon rods, which are heated to incandescence by the passage of an electric current. The upper ends of each set of rods are clamped between water-cooled metal or graphite holders; the lower ends extend into dished carbon blocks holding molten aluminium, to make good contact. The reduced metal is continuously withdrawn through a trap. The second furnace is similar, but employs an external combustion furnace to volatilize the aluminium compound. The third and fourth furnaces are similar to the first and second, respectively, except that the reducing chamber is filled with broken carbon, heated to incandescence either by the passage of an electric current through it or by a combustion furnace below.

No. 648,119, April 24, 1900, Emile Vielhomme, Froges, France.

Produces rich ferrochromium by electrically smelting a charge of 100 parts of chromite, containing oxides of chromium, iron, magnesium, calcium, aluminium and silicon, sufficient broken coke to effect reduction and 20 to 25 parts of a flux, as lime, sand, kaolin or fluorspar. When the metals are completely reduced and fused the heating is continued until the iron is wholly or partially volatilized. The flux gives a fusible slag which acts as a resistance, facilitating easy regulation and the production of a high temperature. It also partially volatilizes and carries off the iron vapor.

No. 648,439, May 1, 1900, Auguste J. Rossi, New York, N. Y.

Produces ferrotitanium, mainly by the reducing action of a molten bath of aluminium or zinc. Carbon may be added, to assist in reduction. The iron is supplied or reduced from its oxide in the charge. The heating is preferably effected by springing an arc between a graphite crucible containing the charge and a depending electrode. Examples: (1) Aluminium, 100 parts, is melted in the crucible, and iron, 50 parts, is then added and melted. Into the bath are fed 275 parts of a briquetted mixture of titanic oxide, 56 per cent, and iron oxide 44 per cent. The charge gradually disappears with incandescence, whereupon the electric current is decreased until the mixture is all melted. The temperature is finally raised, to give a homogeneous alloy, containing 40 to 62 per cent of titanium. (2) A bath of aluminium, 60 to 63 parts, and iron, 125 parts; the charge, 275 parts of a briquetted mixture containing titanic oxide, 56 per cent; iron oxide, 44 per cent, and carbon, 35 to 37 parts. The resulting alloy containing 29.46 per cent of titanium. (3) Titaniferous mixture, 275 parts. Reducing agent, 83 parts, to wit: carbon, 58 to 70 per cent, and aluminium 25 to 30 per cent. Iron, 250 parts. The resulting alloy contains 19.82 per cent titanium. (4) Titaniferous slag, containing 60-62 per cent of titanic oxide, 100 parts: titaniferous ore, 18 per cent titanic oxide, 175 parts; iron, 200 parts; aluminium, 90 parts. The resulting alloy contains 14.08 per cent titanium.

No. 648,463, May 1, 1900, Richard I. Knaur, Austria-Hungary, Harold W. Buck, Schenectady, N. Y., and Charles B. Jacobs, East Orange, N. J.

Produces silicon hydrite by electrically heating a silicious material to incandescence or fusion and treating it with a gas containing hydrogen, *e. g.*, water gas. The silica, clay or other silicious ore is heaped upon the bottom of a furnace chamber, through the end walls of which pass horizontal carbon electrodes. The ore is heated by an arc, sprung between the electrodes near its upper surface. The hydrogen gas is introduced through the bottom of the furnace, and the hydride escapes from the top. The residue, aluminium silicate, is useful as an abradant.